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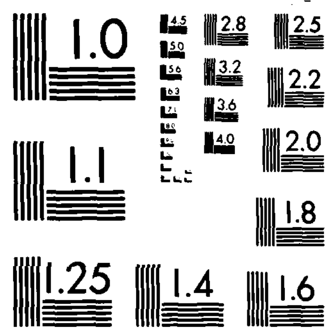

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ARTIFICIAL AND NATURAL ICING TESTS YEH - 60A QUICK FIX HELICOPTER

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JUNE 1984

FINAL REPORT

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USAAEFA

UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
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ECM Antenna Oscillations
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Blade Inspection Method Indicators
Thermoelectrically Anti-Iced DF Dipole Antenna

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Artificial and natural icing flight tests were conducted on the YEH-60A, Quick Fix helicopter (USA SN 79-23301) to establish a moderate icing flight envelope for the helicopter with the AN/ALQ-151(V)2 countermeasures system installed. The tests were conducted at Duluth, Minnesota from 5 January to 21 March 1984. A total of 12.3 flight hours were flown in the icing environment. After damage to an unprotected direction finding (DF) dipole antenna during an icing encounter, the original DF dipole antennas were removed and a prototype thermoelectrically anti-iced DF dipole antenna installed in position #3 (aft right

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) side). During these tests ~~four~~ deficiencies and ~~sixteen~~ shortcomings were noted. The two icing related deficiencies are: damage to the DF antenna element mounts and phenolic blocks caused by excessive element oscillations induced by ice accumulation and erroneous readings on the Rosemount Icing Rate Indicator caused by Electromagnetic Interference from the Electronic Countermeasures (ECM) system which prevents simultaneous safe operation of the ECM system and the blade deicing system. The two non-icing related deficiencies are: interference between the main rotor blades and the upper elements of the aft (#3 and #4) DF dipole antennas during rearward ground taxi and the inadequate cabin heat. The major shortcomings are: ECM antenna oscillations induced by ice accumulation, poor reliability and high maintenance requirement of the main rotor blades as indicated by red "failed" bands on the Blade Inspection Method indicators, and the accumulation of chaff in the tail rotor slip ring assembly which shorted out the tail rotor blade deice system. Nine additional shortcomings were identified. The YEH-60A Quick Fix helicopter as originally configured (unheated DF antennas) was not suitable for flight in a moderate icing environment. The thermoelectrically anti-iced DF dipole antenna demonstrated safe operation in icing intensities through moderate. The YEH-60A Quick Fix helicopter, as originally configured for this test, should not be cleared for flight in icing conditions. The YEH-60A with anti-iced DF dipole antennas has good potential for flight in moderate icing conditions.

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION SYSTEMS COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO. 63120-1798

REPLY TO
ATTENTION OF

AMSAV-E

SUBJECT: Directorate for Engineering Position on the Final Report of USAAEFA Project No. 83-21, Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

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1. The purpose of this letter is to establish the Directorate for Engineering position on the subject report. The objective of the icing tests was to evaluate the YEH-60A with the installed Quick Fix System external configuration changes to insure satisfactory operation consistent with the moderate icing envelope capability of the basic UH-60A. In addition to the installed Quick Fix System configuration, the test helicopter incorporated aircraft survivability equipment which was also evaluated to insure satisfactory ice accretion and shedding characteristics. Numerous shortcomings identified were related to the operation of the Quick Fix System and not the impact of ice accretion and shedding of the external configuration.

2. This Directorate agrees with the report conclusions and recommendations and the following additional comments are provided. Comments are directed to the paragraph of the report as indicated below:

a. Paragraph 33a: The unheated DF antenna resulted in ice accretion on the elements followed by excessive oscillation and subsequent failure of the phenolic blocks securing the antennas. This is a deficiency. Heated antennas were successfully tested prior to completion of the icing tests and performed satisfactory and eliminated the preceding deficiency. However, the heating elements used within the antennas need to be optimized with respect to power usage. An ultimate solution is being considered which would use flush mounted antennas. It is anticipated that a flush mounted design will not be ready for installation prior to IOC, consequently a new interim design which incorporates heating elements needs to be re-evaluated under icing conditions to insure safe operation.

b. Paragraph 33b: The damage caused by the interference between the main rotor blades and the upper elements of the aft (#3 and #4) DF antennas during rearward taxi is a deficiency. This situation can be eliminated in rearward taxiing by restricting the YEH-60A from such operations. However, the potential still exists to cause damage during landings and taxiing under high, gusty wind conditions. The installation of flush mounted antennas as discussed in paragraph 2a above will correct the problem. However, in the interim if the current Quick Fix System configuration is used after IOC, operating restrictions need to be determined to reduce the potential for damage. The Special

Electronic Mission Aircraft Product Manager has accepted the increased usage of antennas due to damage to meet IOC.

c. Paragraph 33c: The erroneous readings on the Rosemount Icing Rate Indicator in the automatic mode are a deficiency. This problem occurs when the ECM system is operated and can cause a potentially dangerous situation under icing conditions. The exact cause is being investigated and is not known but suspected to be either a radiation or conductive problem in the ECM system or the Rosemount system is inadequately shielded. It is expected the deficiency can be corrected before IOC, if not, then it will be necessary to impose operating restrictions such as operating the deicing system in the manual mode during ECM operation.

d. Paragraph 33d: The inadequate cabin heat at the mission equipment operator's station is a deficiency which has been uncorrected for several years. ECP 279, which has been approved, provides for an Environmental Control Unit (ECU) to be included in the EH-60. This ECU, while not meeting full environmental goals for comfort, should be a great improvement over current BLACK HAWKs.

e. Paragraph 34a: Correction of the ECM antennas oscillation caused by accreted ice is not practical due to design considerations. Flush antennas are being considered but do not appear feasible at this time due to the technical requirements.

f. Paragraph 34b: The shortcoming associated with the BIM indicators is being addressed separately under the EPR program. While a shortcoming , it is associated with reliability and maintenance requirements, not the Quick Fix System.

g. Paragraph 34c: The accumulation of M-130 chaff in the tail rotor slip ring assembly is a shortcoming from the standpoint of impacting on the test program. However, the chaff buildup in the slip ring occurred as a test period in which a high number of chaff dispensings were conducted to evaluate the effectiveness of the M-130 system. The orientation of the M-130 for dispensing chaff is optimized for survivability protection. Consequently, the reliability and replacement requirements of the slip ring in light of the protection afforded is acceptable.

h. Paragraphs 34d and 34f: The shortcomings in these paragraphs are associated with the operation of the AN/ASN-132 and are being addressed by the Special Electronics Mission Equipment Product Manager.

i. Paragraph 34e: The tail rotor tip cap damage is considered to be caused by main rotor blade shed and sheds from other locations of the helicopter's airframe where ice accretes. This type of damage is normal and can be expected under icing conditions. The maintenance requirements associated with tip damage are considered acceptable. Suitable means to control shed ice to preclude such damage is not available at this time.

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SUBJECT: Directorate for Engineering Position on the Final Report of USAAEFA Project No. 83-21, Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

j. Paragraphs 34g, 34h and 34i: The shortcomings relative to the ECM system are being evaluated for correction. Relocation of the emergency ECM antennas retract switch, incorporation of an ECM antenna extended advisory light and elimination of the false ice detection indication are considered as design improvements.

k. Paragraphs 35a through 35g: The shortcomings listed in these paragraphs were previously addressed in the referenced reports.

3. Any changes to the Quick Fix System which result in significant external configuration changes to the YEH-60A must be re-evaluated under icing conditions. This is necessary to insure that deficiencies and shortcomings are adequately corrected and no known problems are introduced.

FOR THE COMMANDER:

Vernon L Edwards
for DANIEL M. McENEANY
Acting Director of Engineering

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INTRODUCTION

BACKGROUND

1. The UH-60A, with production deicing kit installed, has undergone natural and artificial icing airworthiness flight tests (refs 1 through 3, app A) and has been cleared for flight into moderate icing conditions. The YEH-60A helicopter Quick Fix System consists of a UH-60A helicopter modified to accept an AN/ALQ-151(V)2 countermeasures system. Artificial and natural icing tests were required to qualify the helicopter, in this configuration, for flight in moderate icing conditions. The US Army Aviation Systems Command (AVSCOM) directed the US Army Aviation Engineering Flight Activity (USAAEFA) to conduct artificial and natural icing tests of the YEH-60A helicopter Quick Fix System (ref 4, app A) during the winter of 1984 in accordance with the approved test plan (ref 5, app A).

TEST OBJECTIVES

2. The primary objective of this test was to conduct limited artifical and natural icing flight tests to provide AVSCOM the basis for establishing a moderate icing flight envelope for the YEH-60A helicopter Quick Fix System. An additional objective of this test was to determine the effectiveness of electrically anti-icing the direction finding (DF) antennas.

DESCRIPTION

3. The UH-60A is a twin-turbine, single main-rotor helicopter capable of day and night operations under visual and instrument meteorological conditions (IMC). Non-retractable wheel type landing gear are provided. The main and tail rotors are both four-bladed, with a capability of manual main rotor blades and tail pylon folding. A UH-60A with the deicing kit installed incorporates a main and tail rotor deicing system and an ice detection system as well as anti-icing for the pilot and copilot windshields, pitot static tubes and their support struts, engines and engine inlets. The test helicopter (S/N 79-23301) was equipped with improved main rotor droop stops (FSN 70105-08151-045). The YEH-60A Quick Fix System consisted of a UH-60A modified to accept an AN/ALQ-151(V)2 countermeasures system. The AN/ALQ-151(V)2 system electronics are contained in two rack assemblies and two operator console assemblies located in the helicopter cabin. The Quick Fix System antennae included two UHF antennas mounted on the underside of the fuselage; one retractable Electronics Countermeasures (ECM) antenna installed on the underside of the fuselage just forward of the transition section; a DF dipole

antenna set mounted on the exterior of the tail cone; and a built-in test equipment antenna located on the rear vertical section of the tail. For a portion of the evaluation, an electronically anti-iced DF antenna replaced one of the standard DF antennae on the right side of the aircraft. The test YEH-60A was also equipped with the cruise Infrared (IR) suppressor kit (FSN 1560-01-126-9454); the AN/ALQ-144 (V) IR Countermeasures Set; the AN/APR-39 Radar Signal Detecting Set; and two M-130 Chaff/Flare Dispensers. A more detailed description of the UH-60A and the YEH-60A is contained in the UH-60A operator's manual (ref 6, app A), the draft supplemental instructions for the YEH-60A (ref 7, app A), and appendix B. A description of the helicopter icing spray system (HISS) installed on CH-47C helicopter, S/N 68-15814, is presented in appendix C. A more detailed description of the HISS and a description of the JU-21A configured with the cloud particle measuring system, used to document the icing environment in which the test aircraft was flown, is presented in reference 8, appendix A.

TEST SCOPE

4. In-flight artificial and natural icing tests were conducted in the vicinity of Duluth, Minnesota, from 6 January to 21 March 1984. A total of 11 icing flights were conducted totaling 12.3 hours. Of these flights, 6 were in the artificial icing environment, totalling 4.5 hours, and 5 were in the natural icing environment totalling 7.8 hours. A 0.9 hour flight was also flown to investigate possible Electromagnetic Interference (EMI) between the helicopter's blade deice system and Quick Fix mission electronics. Maintenance support was provided by the US Army Aviation Development Test Activity from Fort Rucker, Alabama. Tests were conducted at an average gross weight of approximately 15,700 pounds with an average longitudinal center of gravity located at fuselage station 360.4. Average density altitude varied from 830 to 7630 feet. Icing was accomplished at ambient temperatures from -22.5°C to -4°C at average liquid water content (LWC) of 0.15 to 1.16 grams per cubic meter (gm/m^3). Test airspeeds ranged from 93 to 131 knots true airspeed and the main rotor speed was 258 rpm (100 percent). Anti-ice and deice systems were operated continuously while in the icing environment. Flights were conducted with the AN/ALQ-144 (V) IR Jammer and IR suppressor kit installed. A summary of icing test conditions is presented in table 1, appendix F. Flight limitations contained in the operator's manual, Quick Fix supplemental instructions, and the airworthiness release (ref 9, app A) were observed during testing.

d. The poor reliability of the AN/ASN-132 IINS system (para 28).

e. Ice impact damage to the tail rotor tip caps (para 13).

f. The excessively long and complicated normal alignment procedures required for the AN/ASN-132 IINS system (para 24).

g. The poor location of the emergency ECM antenna retract switch (para 25).

h. The lack of an ECM ANTENNA EXTENDED advisory light in the cockpit (para 26).

i. The false illumination of the ICE DETECTED caution light caused by EMI from the ECM system (para 21).

35. The following previously identified icing related shortcomings remain:

a. The failure of the anti-flapping retrainers to return to the shutdown position with ice accumulation (para 30).

b. The large increase in power required with ice accumulation on the rotor system (para 30).

c. The large decrease in power available with engine and engine inlet anti-ice systems ON (para 30).

d. The poor location of the deice system circuit breakers (para 30).

e. The inadequate watertightness of the cockpit (para 30).

f. The ice accumulation on the cockpit steps (para 30).

g. The ice accumulation on the FM homing antennas which interferes with cockpit door opening (para 30).

CONCLUSIONS

GENERAL

32. The YEH-60A Quick Fix helicopter as originally configured (unprotected DF antennas) is not suitable for flight in a moderate icing environment (para 10). Safe operation of the thermo-electrically anti-iced DF dipole antenna was demonstrated in icing intensities through moderate ice conditions to temperatures as low as -22°C (para 10). A total of four deficiencies and sixteen shortcomings exist with respect to the YEH-60A operation in an icing environment.

DEFICIENCIES

33. The following deficiencies were noted and are listed in decreasing order of importance:

a. Damage to the unheated DF antenna element mounts and phenolic blocks caused by excessive element oscillations induced by ice accumulation (para 15).

b. Interference between the main rotor blades and the upper elements of the aft (#3 and #4) DF antennas during rearward ground taxi (para 22).

c. Erroneous readings on the Rosemount Icing Rate Indicator caused by EMI from the ECM system which prevents simultaneous safe operation of the ECM system and the blade deicing system in the automatic mode (para 20).

d. Inadequate cabin heat at the mission equipment operator's station (para 23).

SHORTCOMINGS

34. The following shortcomings were identified and are listed in decreasing order of importance:

a. The ECM antenna oscillations induced by ice accumulation (para 17).

b. The poor reliability and high maintenance requirement of the main rotor blades as indicated by red "failed" bands on the BIM indicator (para 27).

c. The accumulation of M-130 chaff in the tail rotor slip ring assembly which shorted out the tail rotor blade deice system (para 29).

f. The ice accumulation on the cockpit steps.

g. The ice accumulation on the FM homing antennas which interferes with cockpit door opening.

31. The following recommendations still apply from previous UH-60 icing tests since either no corrective action has been accomplished or the corrective action taken was inadequate to warrant deletion of the previous (refs 3 and 4, app A) recommendation:

a. The Windshield Anti-Ice Copilot and Pilot switches should be labeled to indicate the reset feature of the OFF position.

b. The following CAUTION should be placed in the operator's manual immediately:

CAUTION

Continued use of a faulty windshield anti-ice system may result in structural damage (delamination and/or cracking) to the windshield.

c. The following CAUTION should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment:

CAUTION

If ice accumulates on one or more sections of the anti-iced windshields, with the windshield anti-ice system ON, the respective windshield should be turned OFF and the icing conditions exited due to the possibility of engine foreign object damage if the ice should shed from the windshield.

d. The following note should be placed in the operator's manual as soon as possible.

NOTE

During operation in cold weather, particularly when snow or moister is present, the tail wheel locking indicating system gives erroneous cockpit indications.

15.9 flight hours. In this case both the NPU and the Standard Inertial Navigation System (STD INS) failed. A factory representative traveled to Duluth, Minnesota and reprogrammed the NPU and recalibrated the STD INS. No failures were experienced during the remainder of the program and the ferry flight (40.7 flight hours). The poor reliability of the AN/ASN-132 IINS is a shortcoming.

Tail Rotor Slip Ring Assembly

29. The production Black Hawk blade deicing kit was installed and tested on the YEH-60A Quick Fix helicopter prior to initiation of the icing tests. During functional checks on the system, the tail rotor slip ring assembly (FSN 70550-02129-042) and the tail rotor blade deice system failed because of chaff accumulation between the rotor assembly (FSN 70550-02129-105) and the electrical holder assembly (FSN 70550-02129-106). Damage required replacement of the slip ring rotor and electrical holder assemblies. The YEH-60A was equipped with two M-130 Chaff/Flare dispensers mounted on the left side of the aircraft instead of the single M-130 mounted on standard Black Hawk helicopter. The second M-130 fires downward. Extensive chaff firings had been performed during previous mission testing. No chaff was fired during the icing tests. The accumulation of chaff in the tail rotor slip ring assembly which shorted out the tail rotor blade deice system is a shortcoming.

MISCELLANEOUS

30. No corrective action was accomplished for several of the previously identified (refs 3 and 4, app A) shortcomings on the UH-60A in icing conditions and no specific evaluation was accomplished to investigate them. However, the following discrepancies remain:

a. The failure of the anti-flapping restrainers to return to the shutdown position with ice accumulation.

b. The large increase in power required with ice accumulation on the rotor system.

c. The large decrease in power available with engine and engine inlet anti-ice systems ON.

d. The poor location of the deice system circuit breakers.

e. The inadequate water tightness of the cockpit.

fully retracted as indicated by illumination of the ANTENNA RETRACTED advisory light. The emergency ECM antenna retract switch is inaccessible to the pilot and copilot while in flight. The minimum crew required for flight is the pilot and copilot. It is feasible that operation of the ECM antenna might be required with this minimum crew as on a maintenance functional test flight. The poor location of the emergency ECM antenna retract switch is a shortcoming.

ECM Antenna Advisory

26. The position of the ECM antenna is monitored in the cockpit by an ANTENNA RETRACTED advisory light. This light illuminates whenever the ECM antenna is fully retracted and extinguishes whenever the ECM antenna is extended or in transient. The pilot normally has no positive indication that the ECM antenna is extended. The extended ECM antenna could easily be overlooked during a before landing check. The lack of an ECM ANTENNA EXTENDED advisory light in the cockpit is a shortcoming.

RELIABILITY AND MAINTAINABILITY

Main Rotor Blade Spar Pressure Loss

27. Several main rotor blade spar pressure losses, as indicated by red "failed" bands on the Blade Inspection Method (BIM) indicators, occurred during this evaluation. Spar pressure losses occurred on three different blades which were installed in different positions on the main rotor hub assembly. After each failure, the blade spars were reserviced and either ground run or static load tested. New BIM indicators were installed utilizing a slightly larger "O" ring. In all cases, the blades eventually lost main spar pressure a second time requiring replacement. The Equipment Performance Reports submitted by USAAEFA on these main rotor blade pressure losses are presented in appendix G. The poor reliability and high maintenance requirement of the main rotor blades as indicated by red "failed" bands on the BIM indicator is a shortcoming.

IINS Reliability

28. Two IINS failures occurred during the first month (20.4 flight hours) of the program. The helicopter was received on 21 December 1983 and the first failure occurred on 4 January 1984 (after 4.5 flight hours). The Navigation Processor Unit (NPU) failed and required factory reprogramming, but not replacement. The second failure occurred on 18 January 1984 after an additional

HUMAN FACTORS

Cabin Heating

23. Cabin heating was evaluated throughout the test. The cockpit and cabin of the YEH-60 is heated by bleed-air distributed by a blower through cockpit and cabin ducting. There are six heater outlets located in the cockpit and two outlets on the left and right forward cabin overhead (ref 6, app A). Under combinations of cockpit heat outlet position (open or closed), and heater control settings from OFF to HI, the cockpit was consistently warmer than the cabin area. The difference in temperature was such that the copilot and pilot were uncomfortably warm when attired in flight suit and winter weight flight jacket while the occupant of the ECM operator's seat (right side, station 304) was uncomfortably cold despite wearing thermal underwear, flight suit, winter weight flight jacket, heavy insulated boots, and ski gloves. The extreme cold and requirement to wear heavy gloves made operating test gear difficult and would also make operating the ECM console, especially the keyboard, difficult. The inadequate heat at the mission equipment operators' stations is a deficiency.

Integrated Inertial Navigation System (IINS) Alignment

24. The IINS alignment was evaluated as part of engine runup (ref 6, app A). The procedures required to accomplish the alignment were contained in reference 10, appendix A. To achieve maximum accuracy (NORMAL alignment) the aircraft cannot be moved for seven minutes after the alignment is started. To protect the IINS from power surges and transients, alignment cannot be started until the rotor is at 100% RPM (generators operating) and the hydraulic leak test completed. The fuel used during the excessively long alignment procedures reduces available range and on station time. Furthermore, during the alignment a crewmember is required to re-enter present position, magnetic variation, field elevation, and altimeter setting even if these data have been previously entered into the IINS and remain correct. The excessively long and complicated normal alignment procedures required for the AN/ASN-132 IINS system is a shortcoming.

Emergency ECM Antenna Retract Switch

25. The emergency ECM antenna retract switch is mounted on the antenna relay assembly on the ECM equipment rack (station 330). The switch provides backup retraction capability if a failure occurs in the cockpit ECM ANTENNA switch mounted on the instrument panel. To retract the ECM antenna, the emergency switch must be held at the UP position until the antenna is

mode, the false Rosemount readings will cause activation and improper sequencing of the system. Blade damage or runback caused by overheating of the blades could occur. The system could be operated in the manual mode during jamming operations. However, during manual mode operation, incorrect estimate of icing severity could also cause blade damage or runback because of overheating of the blades. Pilot icing experience in icing conditions will determine how accurately a pilot can estimate actual icing rates. If the tactical situation permits, the crew could turn off the ECM jammer for short periods of time to obtain Rosemount Icing readings. The erroneous readings of the Rosemount Icing Rate Indicator caused by EMI from the ECM system which prevents simultaneous safe operation of the ECM system and the blade deicing system in the automatic mode is a deficiency. As an interim measure, recommend that the blade deicing system be operated in the manual mode whenever active ECM jamming operations are being conducted.

21. For the same conditions listed in paragraph 20, EMI between the ECM system and the blade deicing system was evaluated with the blade deicing system turned off. When ECM jamming power was increased, false Rosemount readings caused illumination of the ICE DETECTED caution light, but did not cause activation of the blade deicing system. The false illumination of the ICE DETECTED caution light caused by the EMI from the ECM system is a shortcoming.

GROUND HANDLING

22. Ground handling characteristics of the YEH-60A helicopter were evaluated during the test program. During rearward taxi, one main rotor blade contacted the upper elements of the #3 and #4 DF antennas (photo 13, app H). A combination of aft longitudinal cyclic (approximately 1 1/2-inch), low power setting, strong gusty head winds and aircraft pitch attitude change (as the tail wheel castered) resulted in sufficient main rotor tip path plane tilt to allow antenna contact. The top two inches of each antenna element were severed, the element attachment phenolic blocks were damaged (photo 14, app H) and the tail drive shaft cover was punctured with an element fragment ending up underneath the drive shaft (photo 15, app H). The Equipment Performance Report submitted by USAAEFA on the incident is presented in appendix G. The interference between the main rotor blades and the upper elements of the aft (#3 and #4) DF dipole antennas during rearward taxi is a deficiency.

natural icing encounter of 28 minutes at -20.0°C and an average LWC of 1.0 gm/m^3 is shown in photo 11, appendix H. The M-130 systems were not operated during this evaluation. No ice accretion or subsequent sheds were observed which would interfere with the operation of the system during or after an icing encounter. For the conditions tested, the ice accretion and shedding characteristics of the M-130 chaff/flare dispensers are satisfactory.

AN/ALQ-144 (V) Infrared (IR) Countermeasures Device

19. The ice accretion and shedding characteristics of the AN/ALQ-144(V) IR Countermeasures device were evaluated at the specific test conditions in table 1, appendix F. Those characteristics were documented in artificial and natural icing conditions as depicted in figures 1 and 2, appendix F, respectively. For most test flights the ALQ-144(V) was activated before entry into the icing conditions. Typical ice accumulation after a 28 minute flight in artificial icing conditions at 1.0 gm/m^3 LWC and -20.0°C is shown in photo 12, appendix H. To test the capability of the device to shed accumulated ice, the ALQ-144 was activated after an artificial icing encounter of 43 minutes at -6.5°C and an average LWC of 1.0 gm/m^3. Activation of the ALQ-144 melted the ice touching the lens and the remaining ice shed naturally. Evaluating the effects of ice accumulation on the operating characteristics of the ALQ-144(V) was beyond the scope of these tests. The ice accumulations and subsequent sheds from the ALQ-144(V) after exposure to natural and artificial icing conditions did not adversely affect the operation of the helicopter. For the conditions tested, the ice accretion and shedding characteristics of the ALQ-144(V) IR countermeasures device are satisfactory.

ECM SYSTEM ELECTROMAGNETIC INTERFERENCE (EMI)

20. EMI between the ECM system and the YEH-60A's anti-icing and deicing systems was evaluated during a 1.4 hour flight. The average gross weight for this test was 15950 lb with an average longitudinal center of gravity location of FS 360.5, an average density altitude of 1600 ft, and an average outside air temperature of -17°C. A mission specialist operated the ECM system for these tests. Activation of the aircraft's anti-icing and deicing systems did not affect operation of the ECM system. However, activation of the ECM system caused erroneous readings on the Rosemount Icing Rate Indicator. As jamming power was increased, the indicator reading increased from 0 to .5 gm/m^3. If the helicopter blade deicing system is turned on in the automatic

on the unheated sections of the DF antenna elements and supports is shown in photo 8, appendix H taken after an artificial icing flight during which the antenna was exposed to LWC ranging from 0.50 to 1.0 gm/m^3 at -22.5°C for 30 minutes. No antenna oscillations were observed in artificial or natural icing or in clear air tests. The anti-iced DF dipole antenna was designed only to test the feasibility of antenna anti-icing and was not configured to DF. No electromagnetic interference was noted between the heated DF dipole antenna elements and other aircraft systems. The thermo-electrically anti-iced DF dipole antenna demonstrated safe operation in icing intensities through moderate, and has good potential for flight in icing conditions. Further testing of a production configured anti-iced DF dipole antenna should be accomplished in artificial and/or natural icing conditions to verify proper operation.

Electronic Countermeasures (ECM) Antenna

17. The ice accretion and shedding characteristics of the ECM antenna were evaluated at the specific test conditions listed in table 1, appendix F. The ECM antenna was iced in the retracted and extended positions. Typical ice accumulation on the extended antenna after 49 minutes exposure to artificial icing conditions at 1.0 gm/m^3 LWC and -21.5°C is shown in photo 9, appendix H. Ice accumulation induced an oscillations on the ECM antenna causing tip deflections of up to ±1 foot. The oscillations also caused noticeable movement of ECM antenna actuation mechanism and the adjoining mounting structures. The oscillations occurred approximately every 10 minutes in moderate icing conditions and usually lasted between 10 and 30 seconds ending when the accumulation ice was shed. Shedding could also be induced by retracting and extending the ECM antenna (photo 10, app H). In the retracted position the ECM antenna and its actuation mechanism accumulated only small amounts of ice which did not prevent antenna extension or retraction. Post flight inspections revealed no damage to the antenna or the mount following icing encounters. The operational characteristics of the ECM antenna after ice accumulation or while oscillating were not evaluated. The excessive ECM antenna oscillations caused by ice accumulation are a shortcoming.

M-130 Chaff/Flare Dispensers

18. The YEH-60A Quick Fix helicopter has two M-130 chaff/flare dispensers mounted on the left side of the tail cone just aft of the transition section. The ice accretion and shedding characteristics of these dispensers were evaluated during the artificial and natural icing conditions outlined in table 1, appendix F. A typical residual ice accretion documented after landing from a

oscillations induced by ice accumulation. Ice did not form on the anti-iced portions of the prototype heated DF dipole antenna.

Unheated Direction Finding (DF) Dipole Antennas

15. The ice accretion characteristics of the unheated DF dipole antennas were evaluated at the specific test conditions listed in table 1, appendix F. Ice accumulation caused the unheated DF antennas to oscillate. Flight in artificial icing conditions (1.0 gm/m^3 LWC at -20.0°C) was terminated after 28 minutes behind the HISS when the chase aircraft observed ± 4 inch tip oscillations of the DF antenna elements. Post flight measurement recorded 1.5 inches of ice on portions of the DF antenna elements (photo 4, app H). No damage to the DF antennas or their mounts was noted. However, post flight inspection of the DF antennas after 74.5 minutes in natural icing conditions (0.35 gm/m^3 LWC at -11.0°C) revealed that the phenolic support block of the front right DF antenna (#3) had cracked (photo 5, app H) and the mounting screws for the antenna elements of the rear right antenna (#4) had loosened (photo 6, app H). Further testing of the unheated antenna configuration was suspended following this flight. The Equipment Performance Report submitted by USAAEFA on the incident is included in appendix G. The effect of ice accumulation on the proper function of the DF system was not tested. The damage to the unheated DF antenna element mounts and phenolic blocks caused by element oscillations induced by ice accumulation is a deficiency. Further testing of the effect of ice accumulation on the proper function of the DF system should be accomplished.

Heated DF Dipole Antenna

16. The ice accretion characteristics of a thermo-electrically anti-iced DF dipole antenna were evaluated at the specific test conditions listed in table 1, appendix F. These characteristics were documented in artificial and natural icing conditions as depicted in figures 1 and 2, respectively. Before starting icing tests, the anti-iced antenna was flown in clear air and antenna surface temperature recorded as a function of airspeed and altitude (fig. 3, app F). The anti-iced DF antenna was mounted in position #3, the aft antenna mounted on the right side of the tail cone (photo 7, app H). All other DF antennas were removed for subsequent icing tests. The antenna's anti-ice protection was provided by 900 watt heater elements bonded inside each antenna element. Heated operation was manually controlled by cabin and cockpit mounted switches. No ice accumulation was noted on the heated portions of the DF antenna elements during flight in either natural or artificial conditions. Ice accretion

position. Tail rotor tip caps were damaged during flights under both artificial and natural icing conditions.

Droop Stops

12. The ice accretion and operational characteristics of the droop stops were evaluated throughout these tests. The droop stops installed on the test aircraft were referred to as the improved droop stop configuration (FSN 70105-08151-045). Anti-ice protection was provided by an electrically heated rod inserted through each droop stop pivot bolt. The improved droop stops returned to the retracted (shutdown) position (photo 1, app H) after all tests, incurred no damage, and always seated completely. The improved droop stops operated satisfactorily at all conditions tested.

Tail Rotor Tip Cap Damage

13. Tail rotor tip caps were damaged during flights in both artificial and natural conditions. During a natural icing flight at -5.5°C and LWC of 0.25 gm/m^3 two tail rotor tip caps were damaged and required repair. During an artificial icing flight at -6.5°C and LWC of 1.0 gm/m^3, another tip cap was damaged requiring repair (photo 2, app H). In neither case did the damage cause a noticeable increase in vibrations or change in aircraft handling characteristics. The Equipment Performance Report submitted by USAAEFA on the incident is presented in appendix G. Ice impact damage to the tail rotor tip caps is a shortcoming.

AIRFRAME ICE ACCRETION AND SHEDDING CHARACTERISTICS

General

14. The airframe ice accretion and shedding characteristics of the YEH-60A Quick Fix helicopter were evaluated in both the original configuration and with a prototype, thermo-electrically anti-iced DF dipole antenna installed. Specific test conditions are presented in table 1, appendix F. In flight photographic documentation from chase aircraft and the HISS as well as on board photography was utilized. A photograph of the helicopter with typical ice accretions is shown in photo 3, appendix H. Specific conditions for this photo were 43 minutes of exposure at -6.5 °C and LWC of 1.0 gm/m^3. Ice formed on all stagnation areas and sharp protrusions from the airframe. One deficiency associated with the airframe ice accretion and shedding characteristics was the damage done to the unheated DF dipole antenna element mounts and phenolic blocks caused by excessive element

RESULTS AND DISCUSSION

GENERAL

10. Artificial and natural icing tests were conducted to provide data for establishing a moderate icing envelope (up through 1.0 gm/m^3 LWC) for the YEH-60A Quick Fix helicopter. Antenna and airframe ice accumulation and shedding characteristics were documented. A summary of the specific test conditions for each flight is presented in table 1, appendix F. Additionally, the specific icing conditions in which the YEH-60A was tested are presented in figure 1, appendix F for the artificial environment and figure 2, appendix F for the natural environment. Four deficiencies were noted during the evaluation. The two icing related deficiencies were: (1) damage to the DF antenna element mounts and phenolic blocks caused by excessive element oscillations induced by ice accumulation (2) erroneous readings on the Rosemount Icing Rate Indicator caused by EMI from the ECM system which prevents simultaneous safe operation of the ECM system and the blade deicing system. The two non-icing related deficiencies were: (1) interference between the main rotor blades and the upper elements of the aft DF dipole antennas during rearward ground taxi and (2) inadequate cabin heat. In addition, sixteen shortcomings were identified, seven of which have been previously reported. The major icing related shortcomings noted were: (1) the ECM antenna oscillations induced by ice accumulation and (2) the accumulation of chaff in the tail rotor slip ring assembly which shorted out the tail rotor blade deice system. The icing related deficiencies noted during this test should be corrected prior to further flight in icing conditions and the two shortcomings noted above should be corrected prior to production. The non-icing related deficiencies should be corrected prior to operational release of the aircraft. The remaining shortcomings should be corrected. The YEH-60A Quick Fix helicopter, as originally configured for this test, should not be cleared for flight in icing conditions. The YEH-60A with anti-iced DF dipole antennas has good potential for flight in moderate icing conditions.

ROTOR SYSTEM ICE ACCRETION AND SHEDDING CHARACTERISTICS

General

11. Rotor system ice accretion and shedding characteristics were evaluated throughout these tests. Specific test conditions are listed in table 1, appendix F. No inflight difficulties associated with rotor system ice accretion or shedding were identified. Following flight in both natural and artificial conditions, the droop stops returned to the retracted (shutdown)

and structural compatibility tests were completed throughout the aircraft's authorized flight envelope.

TEST METHODOLOGY

5. Artificial icing was conducted by flying in a spray cloud generated by the HISS. The JU-21A configured with the cloud particle measuring system was used to document the HISS cloud and provide visual chase and photographic documentation while the test aircraft was in the artificial cloud. Ice accretion was also documented on the ground following icing encounters. The UH-60A was immersed in the cloud for the maximum time attainable (limited by HISS fuel and water capacities). A detailed discussion of the test sequence and procedures is contained in reference 5, appendix A.

6. Natural icing tests were conducted by flying in IMC icing conditions under instrument flight rules (IFR). The JU-21A chase aircraft configured with the cloud particle measuring system was used to locate and document the icing conditions. Photos were taken in flight from the JU-21A after the test aircraft exited the icing environment. Close coordination between air traffic control and the chase and test aircraft crews was required to find and stay in the icing environment and to implement in-flight aircraft join-up for photographic documentation. In addition to the coordination, a combination of radar vectoring, navigational aid holding, and block airspace assignment were used. Time in the clouds was limited by the availability of the natural icing conditions and aircraft IFR fuel requirements.

7. A USAAEFA designed and fabricated visual ice accretion measuring device was mounted on the copilot's door and was used to observe the rate of ice accretion on the airframe. One video camera was mounted on the right side of the aircraft to record dipole antenna motion and a second video camera was mounted on the bottom of the fuselage to record ECM antenna motion. A detailed description of special equipment and instrumentation is provided in appendix D.

8. Test techniques, data analysis methods, methods used to determine cloud parameters, and definitions of icing types and severities are presented in appendix E.

9. The installation of the heated dipole antenna required qualitative EMI and structural integrity tests be completed prior to flight in icing conditions. Ground EMI tests were conducted to assure that the operation of any on-board equipment did not adversely affect any functions of the heated dipole antenna and that operation of the heated dipole antenna did not adversely affect the operation of the aircraft and its components. After the completion of the ground EMI tests, inflight EMI tests

RECOMMENDATIONS

36. The deficiencies listed in paragraph 33 a through c should be corrected prior to flight in icing conditions.

37. The deficiency listed in paragraph 33 d should be corrected prior to production.

38. The shortcomings listed in paragraph 34 a through i and paragraph 35 a through g should be corrected.

39. Further tests should be conducted to fully evaluate the effect of ice accumulation on the proper function of the DF system (para 15).

40. Further tests of a production configured anti-iced DF antenna should be accomplished in natural and artificial icing conditions to verify proper operation (para 16).

41. As an interim measure, recommend that the blade deicing system be operated in the manual mode whenever active ECM jamming operations are being conducted (para 20)

42. The Windshield Anti-Ice Copilot and Pilot switches should be labeled to indicate the reset feature of the OFF position (para 31).

43. The following CAUTION should be placed in the operator's manual immediately (para 31).

CAUTION

> Continued use of a faulty windshield anti-ice system may result in structural damage (delamination and/or cracking) to the windshield.

44. The following CAUTION should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment (para 31):

CAUTION

> If ice accumulates on one or more sections of the anti-iced windshields, with the windshield anti-ice system ON, the respective windshield should be turned OFF and the icing conditions exited due to the possibility of engine foreign object damage if the ice should shed from the windshield.

45. The following NOTE should be placed in the operator's manual as soon as possible (para 31).

NOTE

> During operation in cold weather, particularly when snow or moisture is present, the tail wheel locking inditing system may give erroneous cockpit indications.

APPENDIX A. REFERENCES

1. Letter, USAAEFA, DAVTE-TB, October 12, 1979, subject: USAAEFA Project No. 78-05, Artificial and Natural Icing Tests, Production UH-60A Helicopter.

2. Final Report, USAAEFA Report No. 79-19, *Artificial and Natural Icing Tests Production UH-60A Helicopter*, June 1980.

3. Final Report, USAAEFA Report No. 80-14, *Limited Artificial and Natural Icing Tests Production UH-60A Helicopter (Reevaluation)*, August 1981.

4. Letter, AVSCOM, DRDAV-DI, 7 September 1983, subject: Limited Artificial and Natural Icing Tests of the YEH-60A Quick Fix Helicopter.

5. Test Plan, USAAEFA, Project 83-21, *Artificial and Natural Icing Tests, YEH-60A, Quick Fix Helicopter*, December 1983.

6. Technical Manual, TM 55-1520-237-10, *Operator's Manual, UH-60A Helicopter*, 21 May 1979 change 24 dated 23 March 1984.

7. Technical Manual, TM 55-1520-237-10-1, *Draft Supplemental Instructions, YEH-60A Helicopter*, 15 March 1982.

8. Letter, USAAEFA, DAVTE-TI, 22 June 1982, subject: USAAEFA Project No. 80-04-2, Helicopter Icing Spray System (HISS) Evaluation and Improvements.

9. Letter, AVSCOM DRSAV-E, 7 December 1983, and 3 January 1984, 2 March 1984, and 12 March 1984, subject: Airworthiness Release for YEH-60A Helicopter, S/N 79-23301, to Conduct Artificial and Natural Icing Tests.

10. Technical Manual, DEPTM 11-5826-302-12, *Integrated Inertial Navigation System AN/ASN-132(U)*, 17 Nov 1982.

APPENDIX B. DESCRIPTION

GENERAL

1. The test helicopter, S/N 79-23301, is a UH-60A helicopter modified to accept an AN/ALQ-151(V)2 countermeasures system and redesignated the YEH-60A Quick Fix helicopter. A complete deicing kit incorporating main and tail rotor deicing and an ice detection system as well as anti-icing for the pilot and copilot windshields, pitot-static tubes and their support struts, and engine and engine inlets, was installed. The test helicopter was equipped with improved main rotor droop stops (FSN 70105-08151-045). The external modifications required for the AN/ALQ-151(V)2 countermeasures system included the addition of two UHF antennas mounted on the underside of the fuselage; one retractable countermeasures antenna installed on the underside of the helicopter just forward of the transition section; a dipole antenna set mounted on the tailcone exterior; and two M-130 chaff/flare dispensers mounted on the left side of the tailcone (photos 1 through 4). The YEH-60A was also equipped with the AN/APR-39 Radar Signal Detecting Set; the AN/ALQ-144(V) Infrared (IR) Countermeasures Device; the AN/ASN-132 Integrated Inertial Navigation System (IINS); built-in test equipment located in the rear vertical secton of the tail; and cruise engine exhaust IR suppressors (FSN 1560-01-125-9454). Mission electronic equipment was mounted in the cabin area and controlled by two operators. Cockpit instruments and controls allowed the pilot/copilot to control ECM antenna position; conduct secure voice transmission; and interface with the mission equipment operators. Principle dimensions and features of the YEH-60A are presented in the UH-60A's operator's manual (ref 6, app A) and the draft supplemental instructions for the YEH-60A (ref 7, app A).

IMPROVED DROOP STOPS

2. The droop stops installed on the test aircraft were referred to as improved droop stops (FSN 70105-08151-045) and differed from the previously tested (ref 3, app A) production droop stops (FSN 70105-08151-041). The improved droop stops have shortened and thickened counterweight attachment arms to improve thermal conductivity and the rubber bumpers and tungsten washers have been removed (photo 5). The improved droop stops utilized electrically heated rods to provide anti-ice protection. These rods were equipped with quick disconnect cannon plugs.

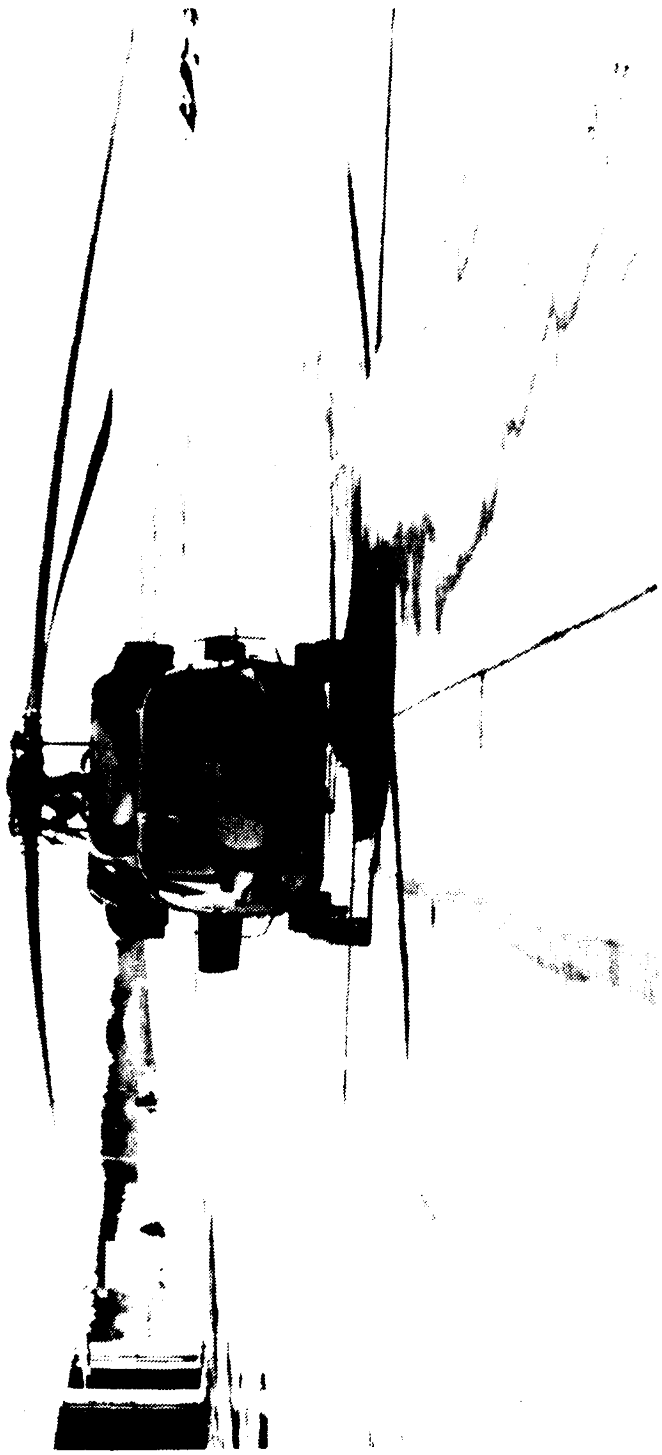


Photo 1. Front View

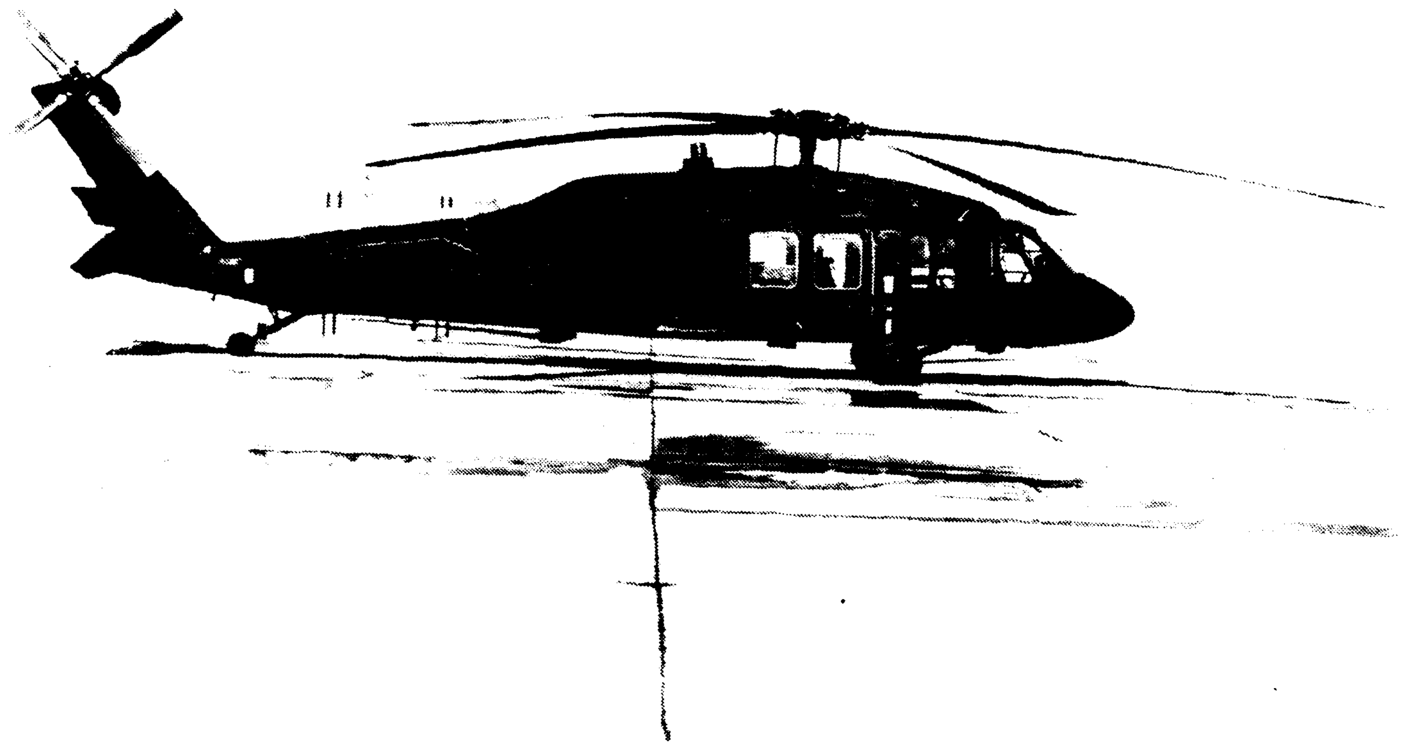


Photo 2. Right Side View

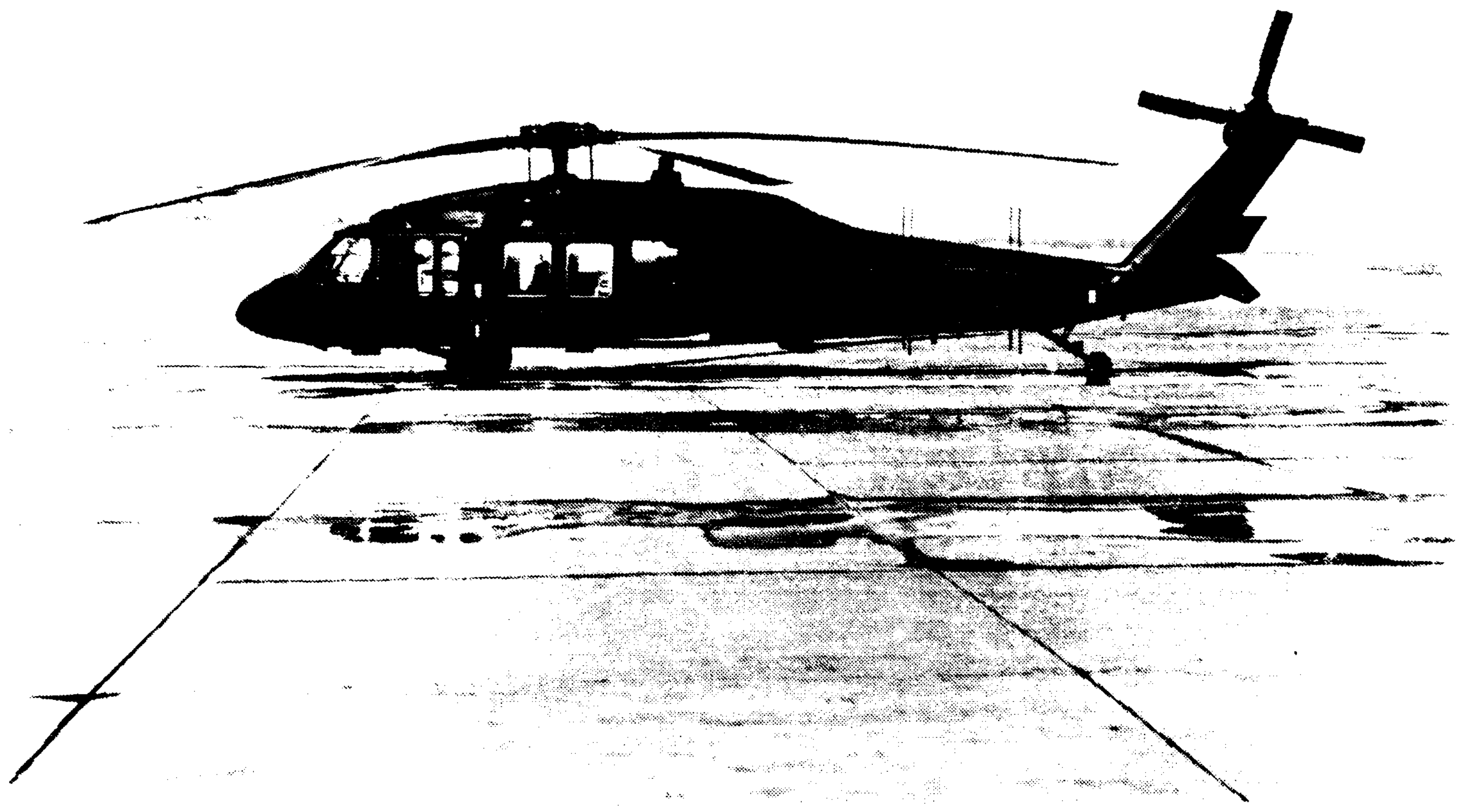


Photo 3. Left Side View

Photo 4. Rear View

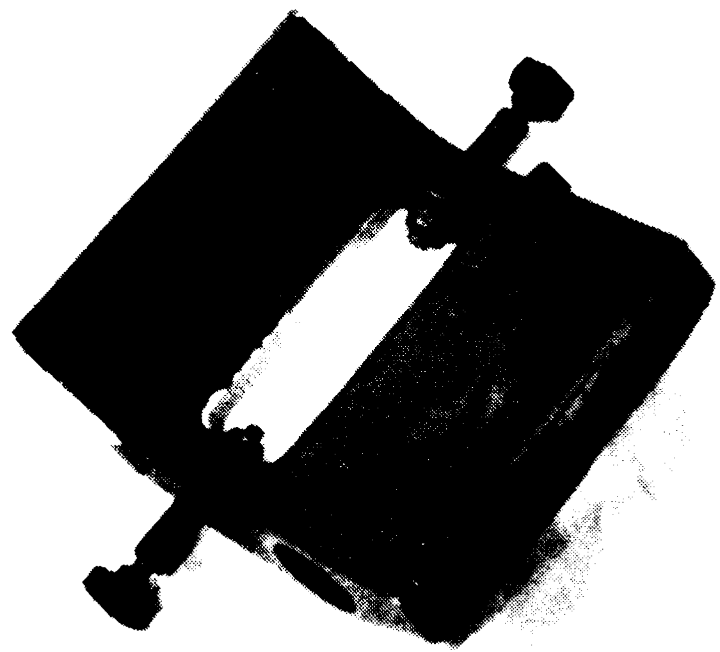


Photo 5. Improved Droop Stop

DIRECTION FINDING (DF) ANTENNAS

General

3. The YEH-60A was initially equipped with a DF dipole antenna set consisting of four antennas mounted on the tailcone exterior. Two antennas were mounted on each side of the tailcone at fuselage stations 536 left and right and 596.6 left and right. Each antenna consisted of two monopole antenna elements, each 40.5 inches long and constructed from 1 inch diameter, 0.080 inch thick hollow aluminum tubing. These monopole elements were attached to phenolic blocks and mounted to the tailcone with a horizontal brace (photo 6). The antenna positions were numbered clockwise with the left rear antenna labeled antenna #4. All electrical wiring was routed internally through the horizontal braces and the tailcone.

Anti-Iced DF Antenna

4. A thermo-electrically anti-iced DF antenna was fabricated and installed at the right rear antenna position (fig. 1). Anti-icing was provided by bonding thermoelectric heaters to the inner surface of two monopole elements (fig. 2). Each heater had approximately 900 watts capacity. The heater could be turned on in the cockpit or cabin and the electrical power supply and control wiring was routed externally along the right side of the tailboom.

ELECTRONIC COUNTERMEASURES (ECM) ANTENNA

5. The ECM antenna is an eight pound 109 inch long monopole antenna mounted on the fuselage just forward of the tailcone assembly (fuselage station (FS) 483) as shown in photos 7 and 8. Constructed of 1/8 inch thick hollow aluminum tubing, its diameter varies incrementally from 3.0 inches at its base to 0.50 inches at the tip. The ECM antenna rotates downward and forward pivoting about the base mounting structure to extend. Power for ECM antenna extension is provided by an electronic actuator controlled by a three-position guarded switch on the center instrument panel (fig. 3). The ECM antenna will automatically retract whenever the copilot's radar altimeter is turned on and the aircraft's absolute altitude becomes less than the value selected on his L (LO SET) indicator. Whenever the ECM antenna is fully retracted, the ANTENNA RETRACTED status advisory light on the caution/advisory panel will go on and remain on. When the antenna is fully extended, a light on the ECM operator's console marked ANTENNA DEPLOYED will go on and remain illuminated until the

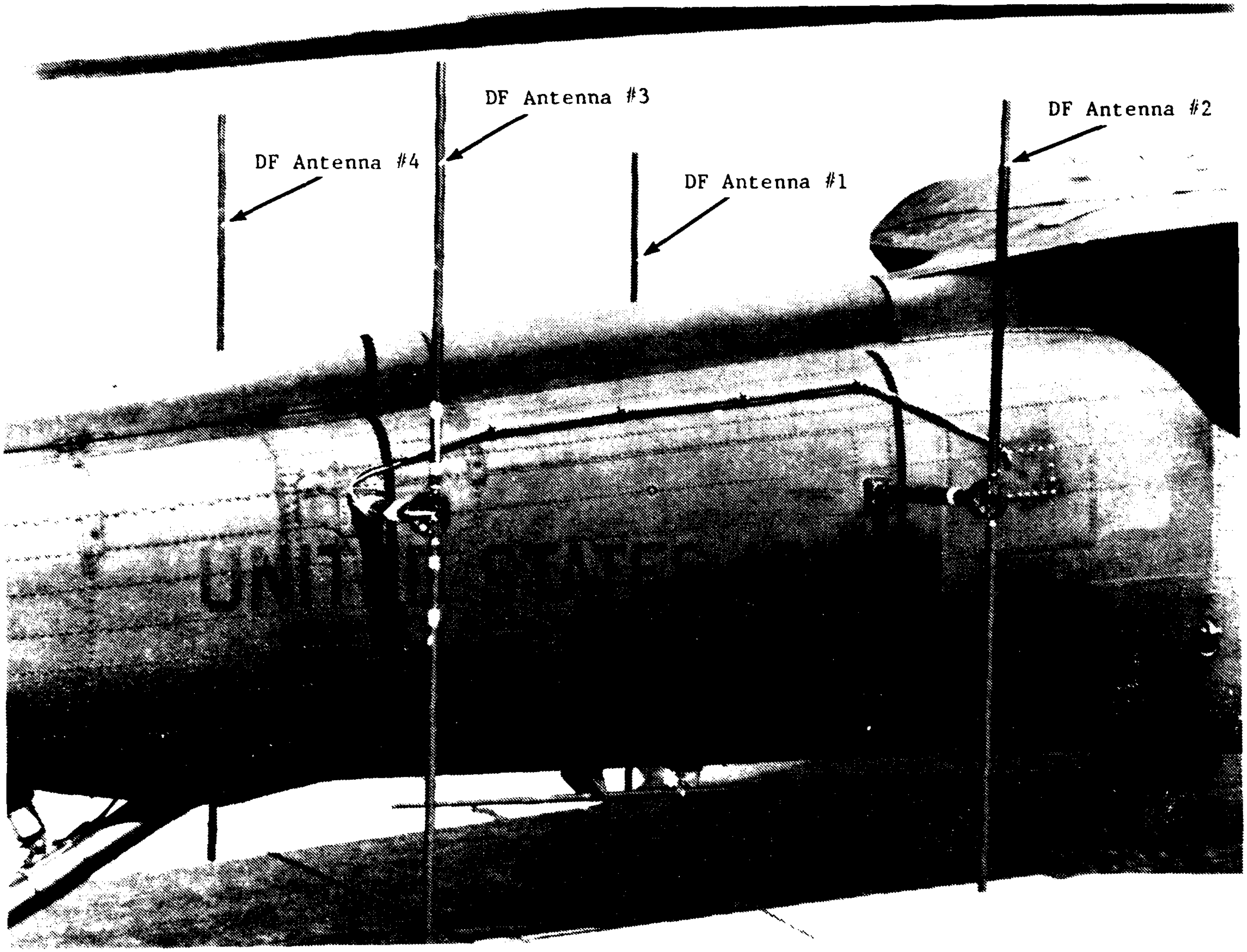


Photo 6. Direction Finding (DF) Dipole Antenna Set

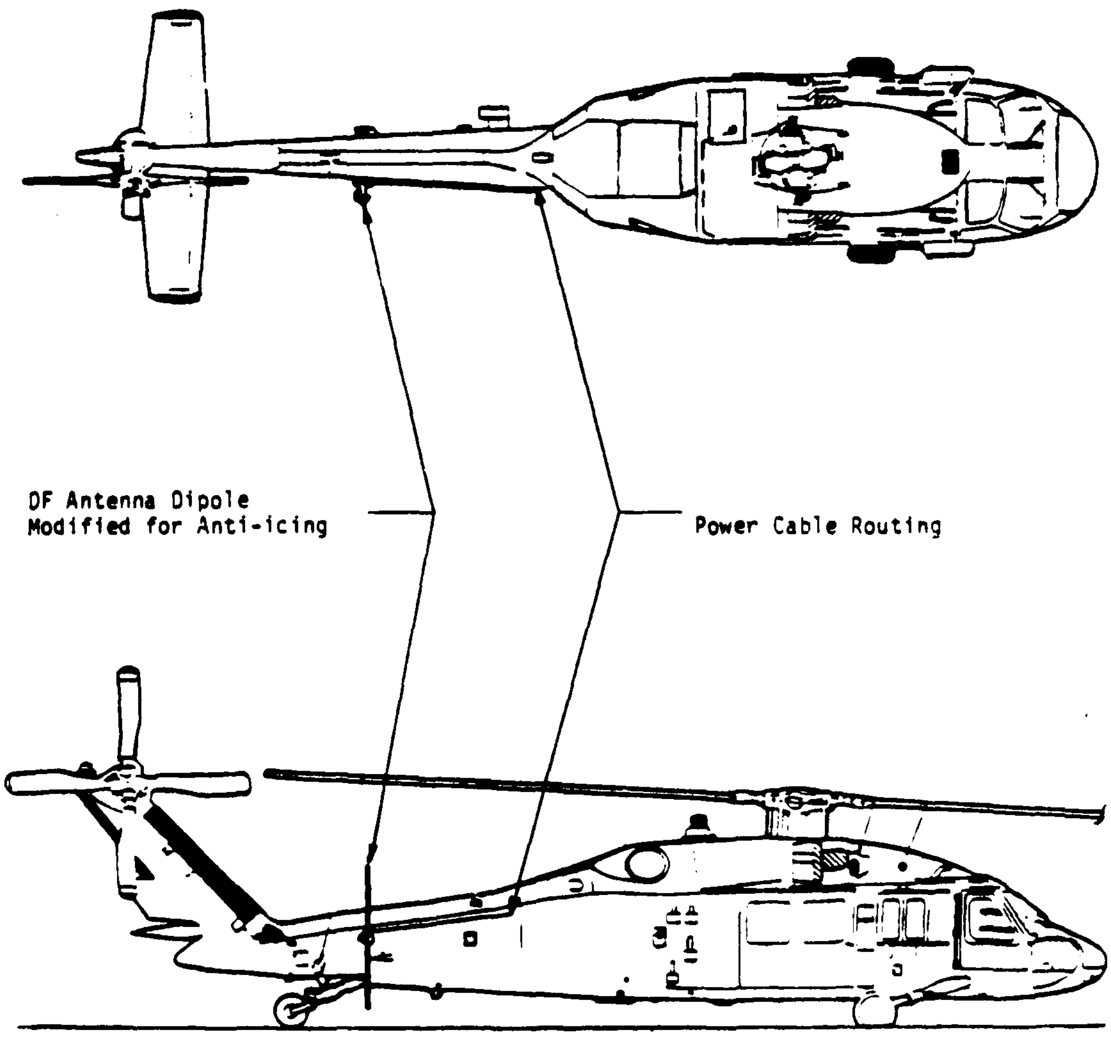


Figure 1. DF Antenna Thermoelectric Anti-Icing Test Installation

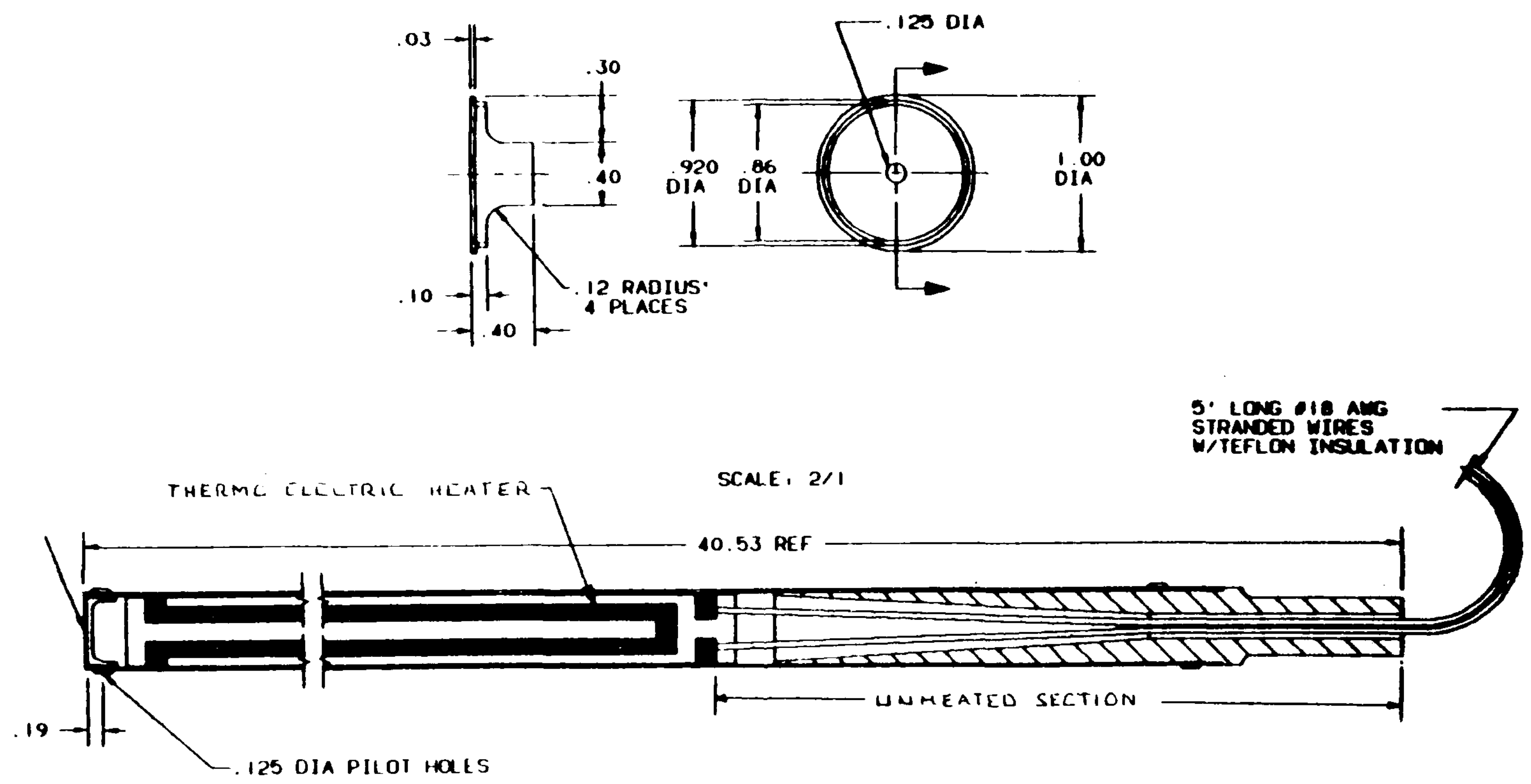


Figure 2. Heated Direction Finding (DF) Antenna Element

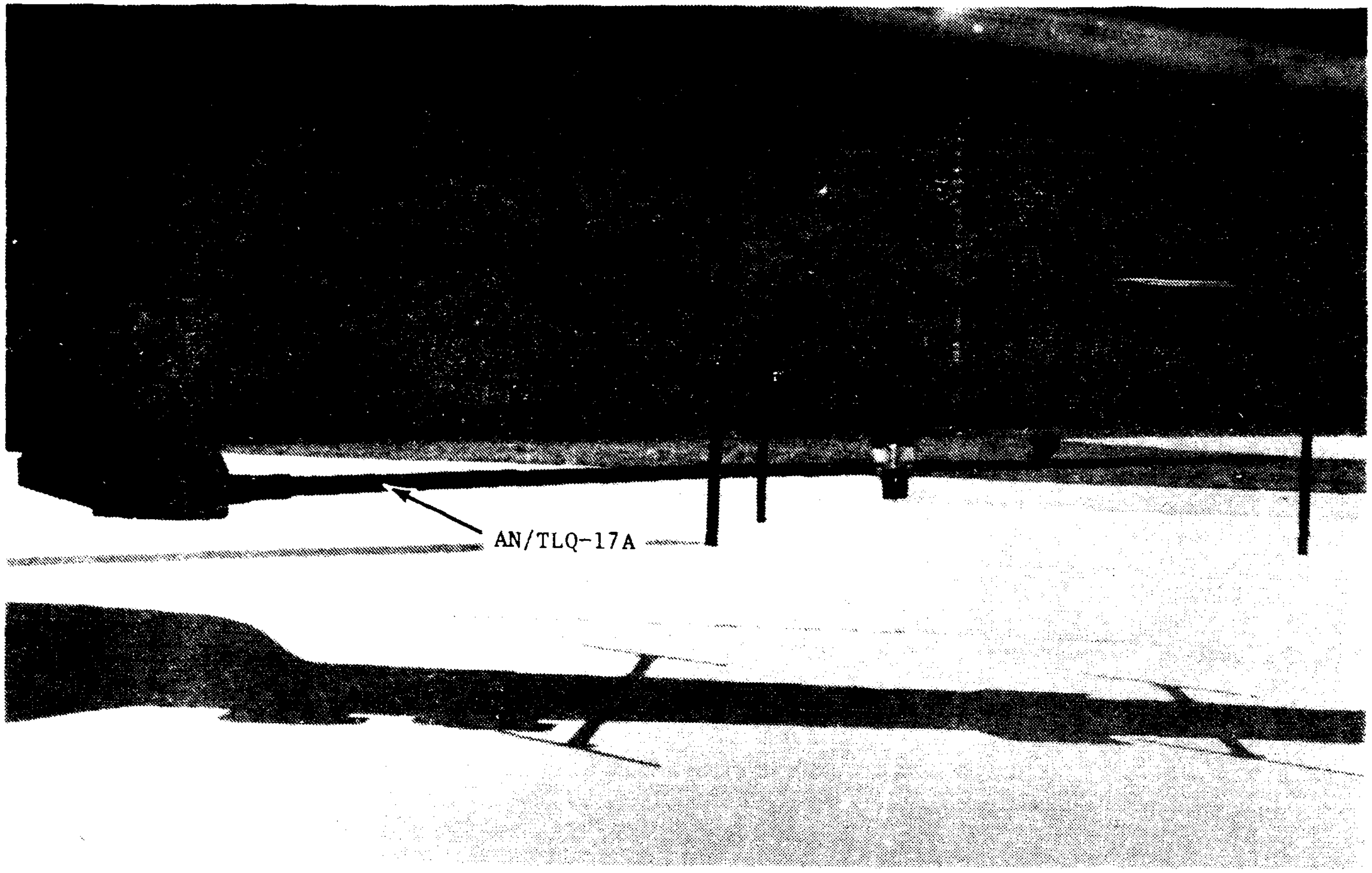


Photo 7. Electronic Countermeasure Antenna - Retracted

APPENDIX D. INSTRUMENTATION

CAMERA SYSTEMS

1. Two video cameras were located on the test aircraft to monitor and document accretion characteristics on the #2 and #3 Direction Finding (DF) dipole antennas and the Electronic Countermeasure (ECM) antenna (photos 1 and 2). Each camera was controlled and powered by a separate battery powered recorder. A switch enabled the engineer to select which camera output was displayed on the single color video monitor mounted at the ECM operator's position. Additionally, a video camera and a 16mm motion picture camera were located on board the chase and HISS aircraft and were used to document the test aircraft both in the spray cloud and after exit from icing encounters. Single lens reflex 35mm cameras were used for still photo (color prints and slides) documentation both in the air and on the ground following icing flights.

VISUAL ICE ACCRETION PROBE

2. A visual ice accretion indicator probe was fabricated and installed on the test aircraft. It was used to give additional visual cues of ice buildup on the aircraft fuselage. The probe was composed of a small symmetrical airfoil section (OH-6A tail rotor blade sections) with 3/16-inch diameter steel rod protruding outward from the leading edge of the center span. The protruding rod was painted with 1/4-inch stripes of contrasting colors which provided a means of measuring ice accumulation. The probe was mounted on the left cockpit door just below the window as shown in photo 3.

HEATED DIRECTION FINDING (DF) ANTENNA TEMPERATURE MONITORING EQUIPMENT

3. Thermocouples were attached to each thermo-electrically heated DF antenna to sense monopole surface temperature. Each thermocouple transmitted a separate signal to a display unit mounted in the cabin area. Temperature was displayed in degrees Celsius to the nearest tenth of a degree. A switch on the display unit allowed the engineer to select the monopole being monitored.

CLOUD SAMPLING EQUIPMENT

4. Icing conditions were measured in both the natural and artificial environments, by a USAAEFA JU-21A fixed-wing aircraft, US Army S/N 66-18008. This aircraft was equipped with the following equipment: a Particle Measuring System (PMS), forward

coloration properties similar to sea marker dye is added to the water to impart a yellow color to the ice.

APPENDIX C. HELICOPTER ICING SPRAY SYSTEM DESCRIPTION

1. The HISS is installed in a modified CH-47C helicopter and consists of an internally mounted 1800-gallon water tank and an external spray boom assembly suspended 19 ft beneath the aircraft from a cross-tube through the cargo compartment. Hydraulic actuators rotate the cross-tube to raise and lower the boom assembly. Both the external boom assembly and water supply can be jettisoned in an emergency.

2. The spray boom consists of two 27 ft center sections, vertically separated by 5 ft, and two 17.6 ft outriggers attached to the upper center section. When lowered, the outriggers are swept aft 20° and angled down 10° giving a tip to tip boom width of 60 ft. The boom is assembled of concentric metal pipe; the inner pipe (1-1/2 in. diameter) acts as the water supply and leads to 30 manifolds spaced approximately 3 ft apart along the boom exterior; the outer pipe (4 in. diameter) contains bleed air from the aircraft engines and bleed air APU, and is fitted with a total of 172 nozzle receptacles on the boom surface. These nozzle receptacles are spaced at one foot intervals along the top and bottom of the boom and are staggered to provide alternating upward and downward ejection ports every six inches.

3. A solar T-62T-40C2 auxiliary power unit (APU) is installed in the HISS aircraft bolted to the trunnion assembly between FS 160 and FS 200. For purposes of safety and noise reduction, the unit is enclosed in a stainless steel box with fiberglass sound proofing. Bleed air from the APU is ducted to a flow mixer which combines aircraft engine bleed air with APU bleed air. The combined APU and engine bleed air enters the boom through flexible tubing leading to the boom air intake pipes on either side of the cabin. Electrically-operated valves which are actuated from a single control panel are installed in the system to control both bleed air and water flow rates.

4. A calibrated air temperature probe and a Cambridge dew point hygrometer provide accurate ambient temperature and humidity measurement. A radar altimeter with aft-facing antenna is mounted on the CH-47 to allow positioning the test aircraft at a known standoff distance. The radar altimeter is wired to red and yellow station-keeping lights on the underside of the aircraft. These lights provide a visual indication to the test aircraft for maintaining the proper standoff distance.

5. Because of gross weight limitations, only 1425 gallons of water are carried. To facilitate photographic documentation during icing tests, a non-toxic, biodegradable chemical with

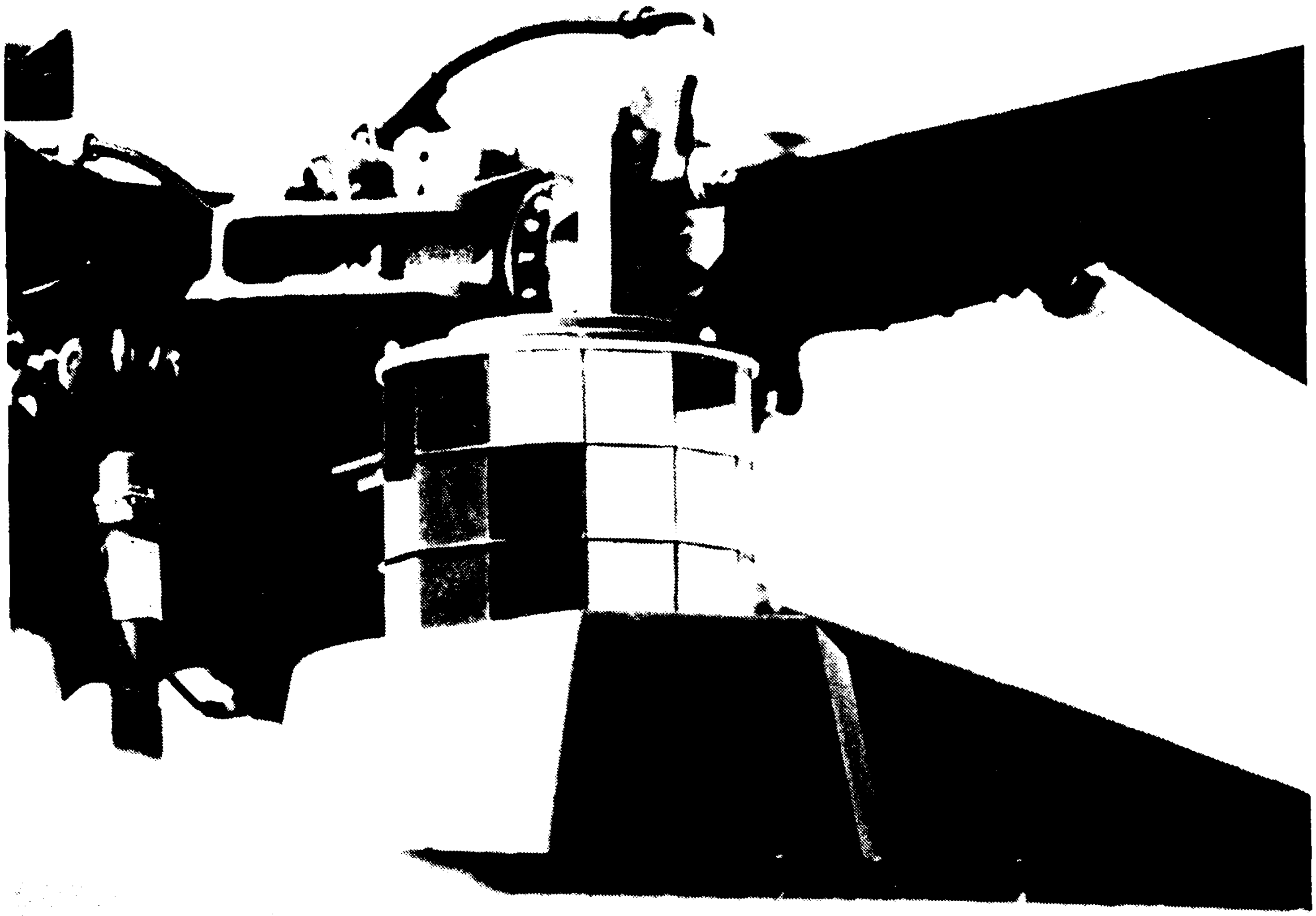


Photo 12. AN/ALQ-144(V) Infrared Countermeasure Set

at high and low frequencies using an electrically-heated source. A built-in test feature monitors system operation and alerts the pilot should a malfunction occur. The system is made up of a control panel on the instrument panel and a transmitter on top of the main rotor pylon aft of the main rotor (photo 12). When the control unit ON-OFF switch on the control panel is momentarily placed ON, the power distribution and control circuits are activated, the source begins to heat, the servo motor and drive circuits are energized, turning on the high and low speed modulators, and a signal is applied to stabilize system operations before energizing the built-in test function. After a warmup period, the stabilizing signal is removed, and the system operates normally. Placing the ON-OFF control switch momentarily to OFF causes the power distribution and control circuits to de-energize the source and initiates a cool-down period. During the cooldown period, the servo motor drive circuits remain in operation, applying power to the motors that cause the modulators to continue turning.

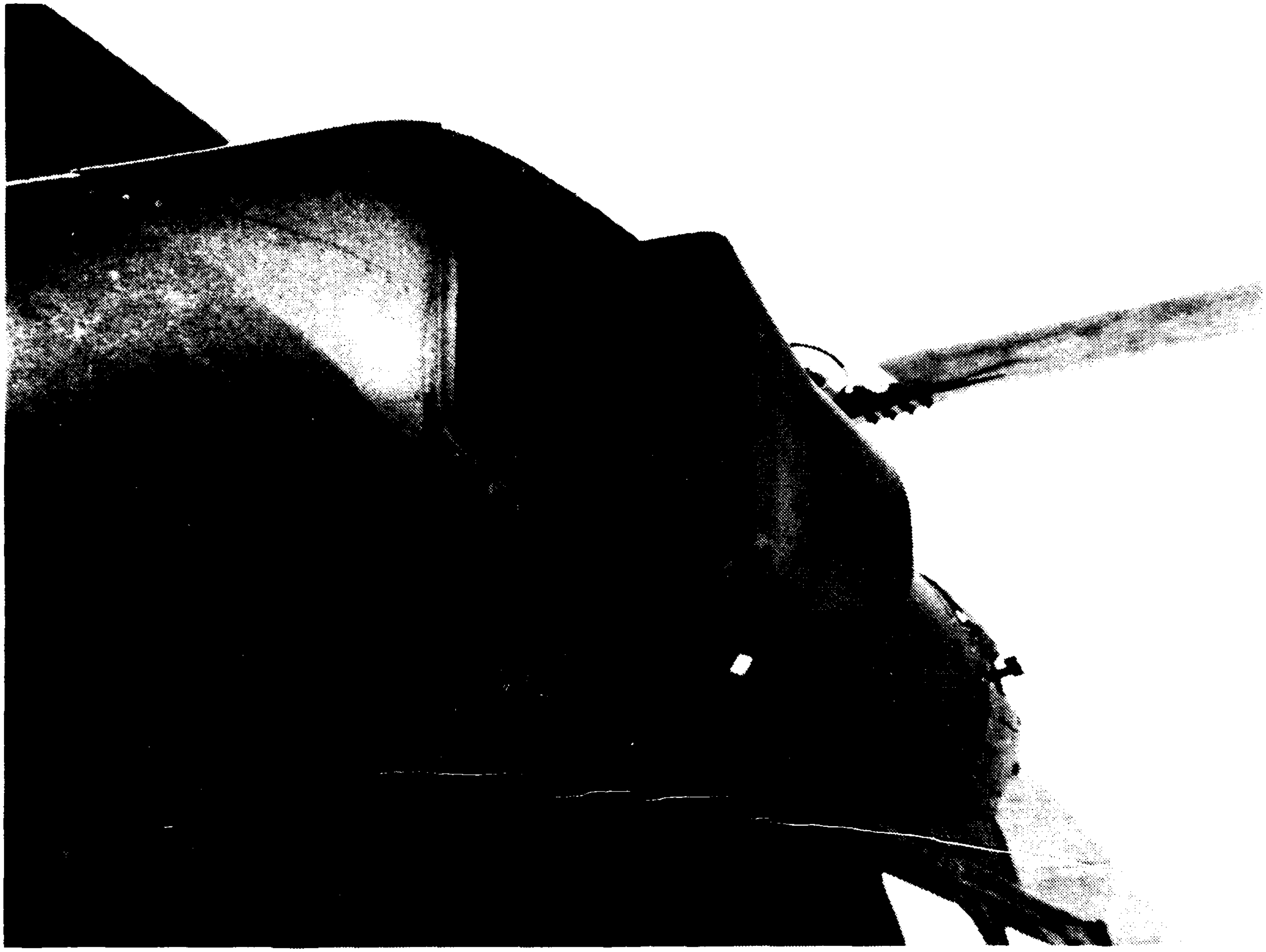


Photo 11. Infrared Radiation Suppressor Kit
(Right Side)

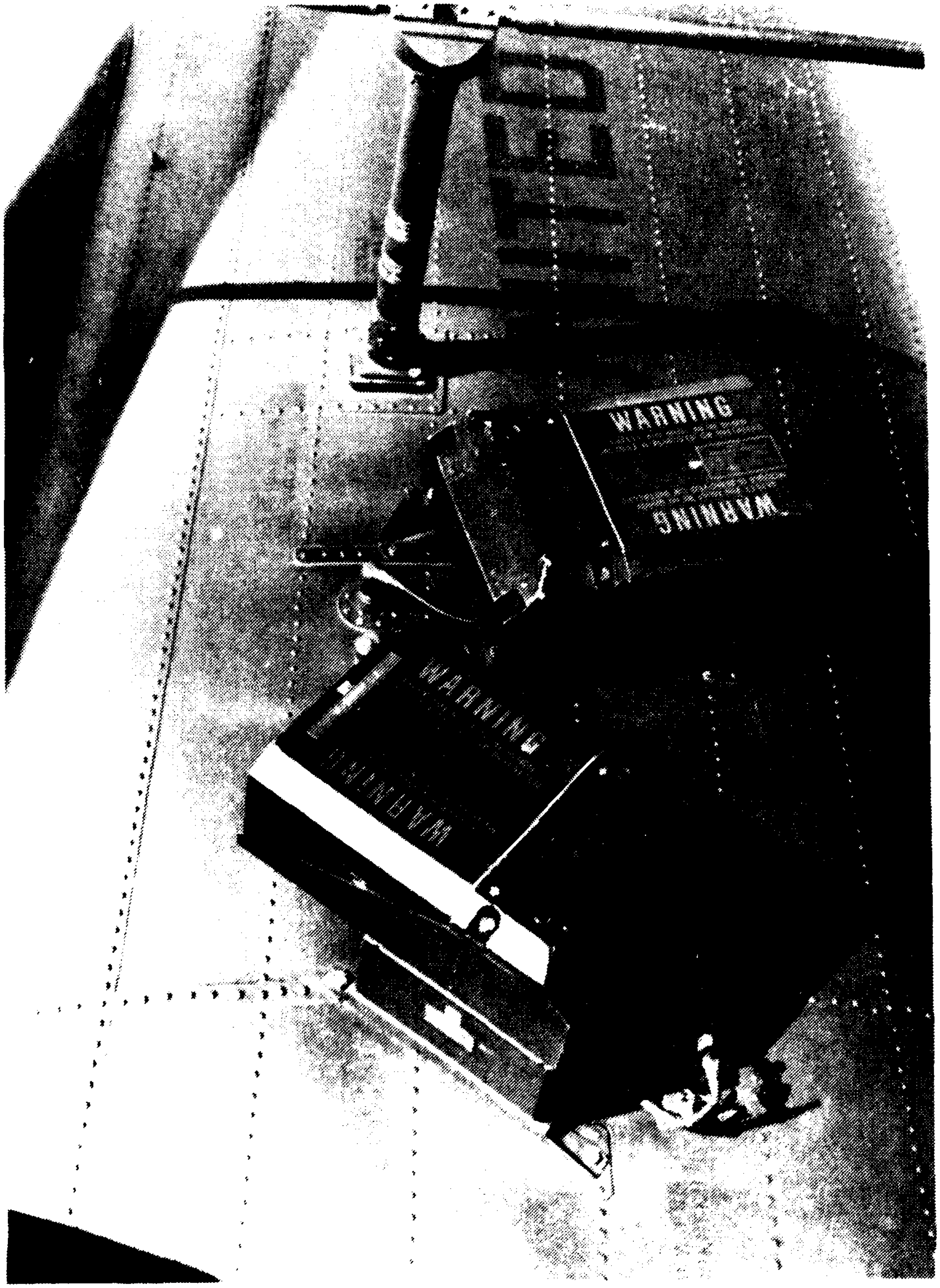
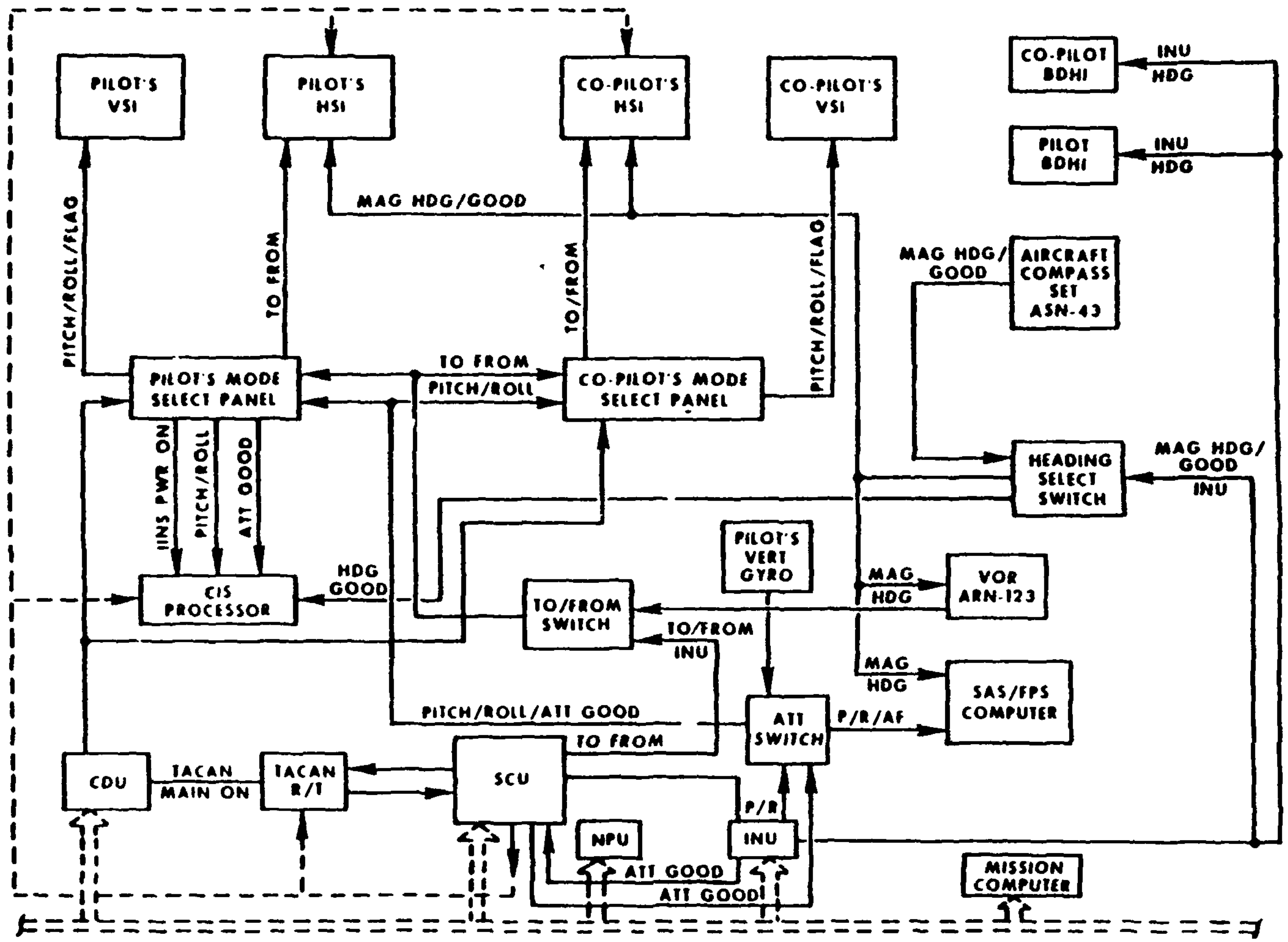


Photo 10. M-130 Chaff/Flare Dispensers



NOTE: Dash lines indicate power BUS tie-in.

Figure 5. Interface of AN/ASN-132 YEH-60A

ray tube. In addition to providing navigation information, the IINS is interfaced with the aircraft flight instruments and altimeter/encoder AAU-32A as outlined in figure 5. The attitude gyroscope (CN-1314) outputs, which supply pitch and roll inputs to Automatic Flight Control System (AFCS) for standard UH-60A helicopters, are replaced by appropriate outputs from the IINS. Heading information from the IINS also replaced the aircraft's AN/ASN-43 compass inputs to the AFCS. A bank of three switches provides the capability to select either IINS or standard helicopter information inputs to the AFCS.

Chaff/Flare Dispenser (M-130) System

9. The YEH-60A is equipped with two M-130 General Purpose Dispensers to provide survival countermeasures against radar guided weapons and infrared seeking missiles. The systems are mounted on the left side of the tailcone (photo 10) and consist of two dispenser assemblies, payload modules, and electronic modules. The dispenser control panel and chaff dispense pushbutton are mounted on the lower console. The flare dispense pushbutton is mounted on the instrument panel.

Infrared Radiation (IR) Suppression Kit

10. The IR suppression kit (photo 11) has no moving parts. It reduces the helicopter's IR signature by mixing ram air with the engine exhaust gases, and by blocking line-of-sight view of hot metal parts. The IR suppressor channels exhaust gases through a sheet metal core mounted within a fiberglass honeycomb sandwich-constructed nacelle. The suppressor core is constructed of short segments; each successive segment, in the direction of gas flow, has a larger cross-sectional area than the previous one. The inside surface of each segment is coated with low-reflectance material. Cooling air, entering the ram inlet scoop, is ducted around the suppressor core and passes through the gaps between overlapping core segments, providing film-cooling of the core surface. The engine exhaust plume is cooled internally by mixing the core film-cooling air, and externally by crossflow mixing with ambient freestream at the suppressor exit. The core turns outboard to prevent line-of-sight seeking of the hot engine turbine and rear frame and to direct the engine exhaust into the free-stream air at a 75° angle to promote rapid exhaust mixing/cooling.

Infrared Countermeasure Set AN/ALQ-144(V)

11. The countermeasures system provides infrared countermeasure capability. The system transmits radiation modulated mechanically

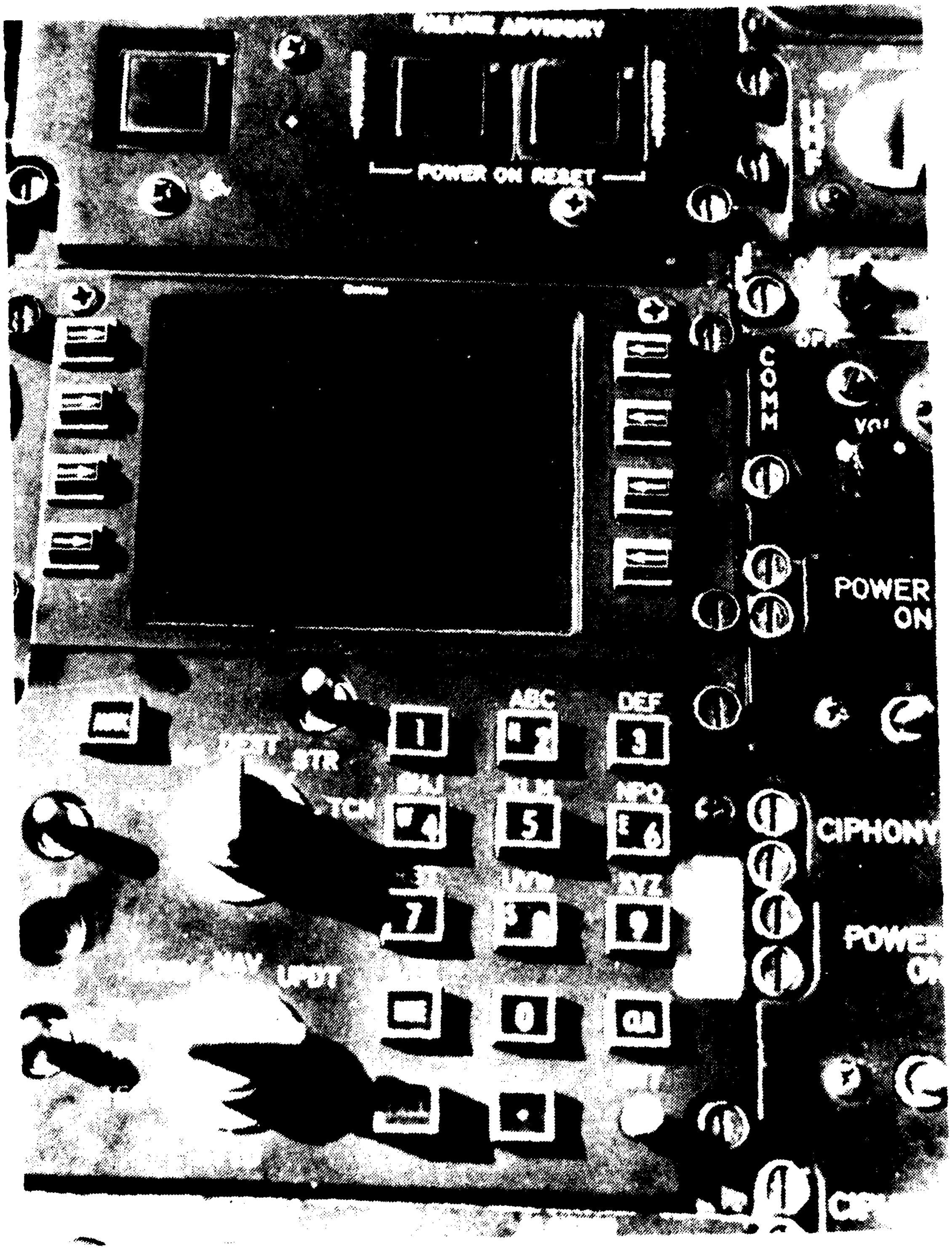
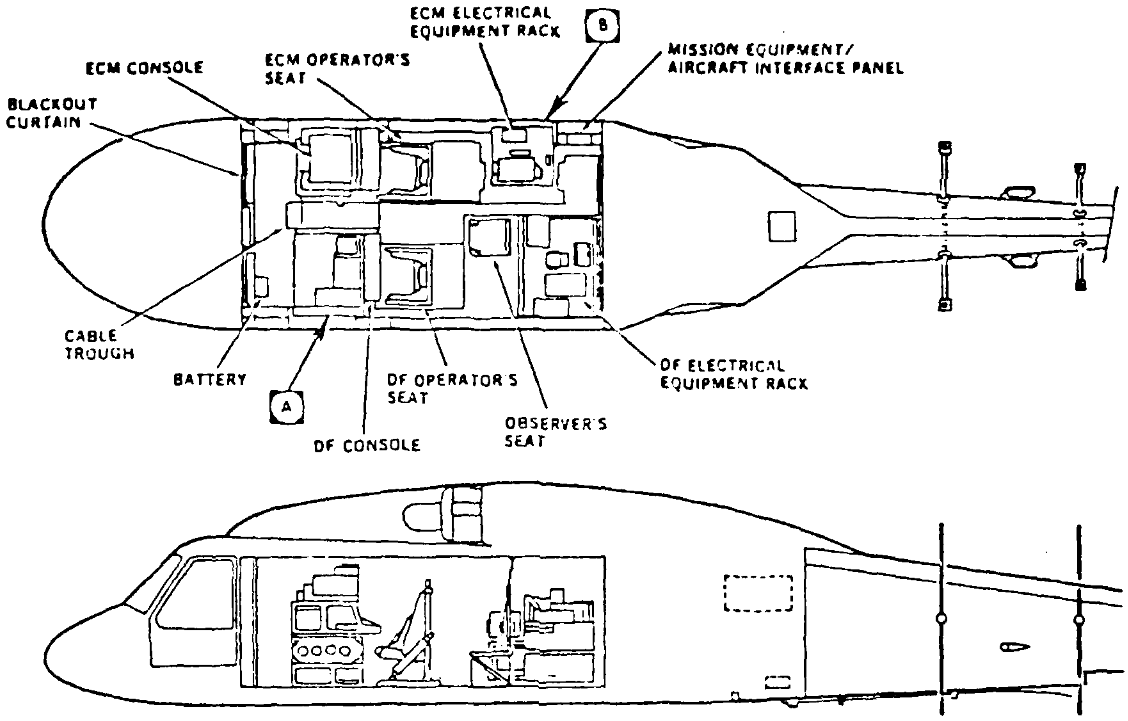
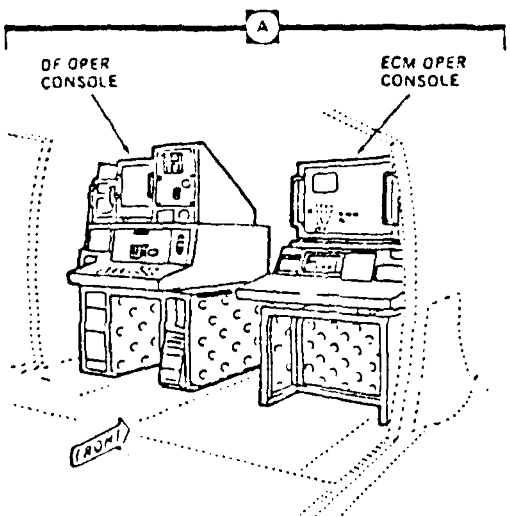


Photo 9. Integrated Inertial Navigation System
Central Display Unit (CDU)





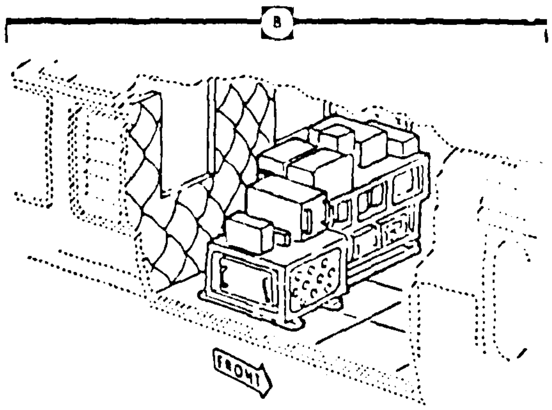


Figure 4. Cabin Equipment Arrangement

antenna is fully retracted. The ANTENNA EXTENDED caution light on the caution/advisory panel will also remain illuminated as long as the antenna is not fully retracted and at least one of these conditions exist: the helicopter is below the radar altimeter LO bug setting; power is lost; or the AN/APN-209 is turned off or removed.

MISSION EQUIPMENT

AN/ALQ-151(V)2

6. The AN/ALQ-151(V)2 radio countermeasures system is capable of detecting radiated RF signals, automatically referencing the location of the transmitte , and initiating active countermeasures against the emitter. The systems consist of six subsystems: direction finder group; intercept group; communications group; computer/navigation group; active countermeasures group (AN/TLQ-17A); and system power group. The electronic surveillance measures (ESM) equipment and the electronic countermeasures (ECM) equipment operate independently of each other. A DF (ESM) operator controls the electronic surveillance functions and the ECM operator controls the active countermeasures functions. These operations interface via the system intercommunications network. The majority of the equipment is housed in the cargo compartment, as shown in figure 4. Additional equipment is located in the tail, tailcone, nose, and cockpit.

AN/ASN-132, INTEGRATED INERTIAL NAVIGATION SYSTEM (IINS)

General

7. The AN/ASN-132 IINS provides self-contained, world-wide position and navigation information which can be automatically updated wherever TACAN facilities exist or manually updated without TACAN data. The IINS uses a gyrostabilized, four gimbal, all attitude platform to measure aircraft acceleration and provide present-position and velocity data, course-line information, steering commands, and angular pitch, roll, and heading information.

Installation

8. The AN/ASN-132 Control and Display Unit (CDU) contains the IINS operating controls and indicators and is mounted on the lower center console (photo 9). The CDU enables the operator to enter data and control the information displayed on the cathode

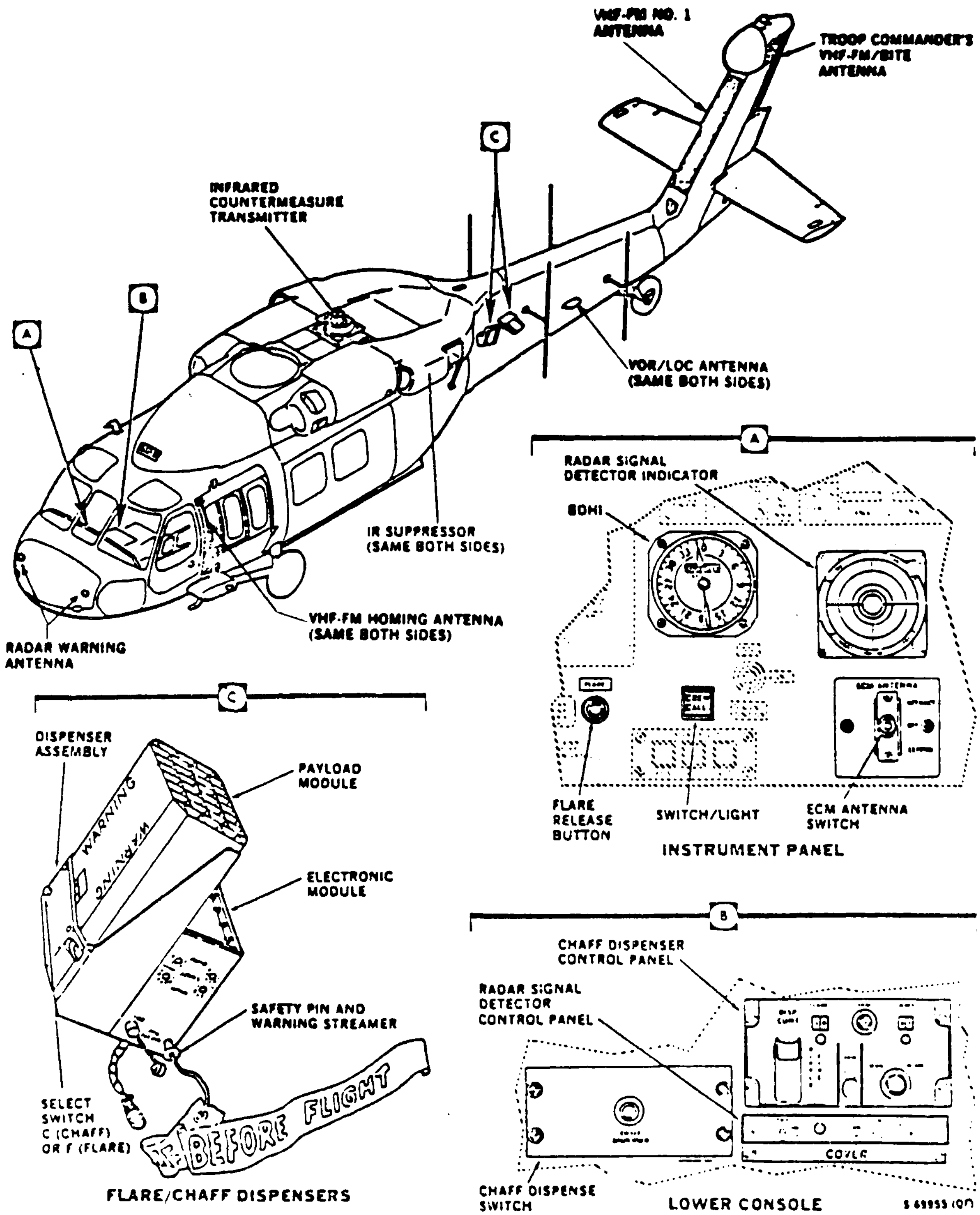


Figure 3. Mission Kits

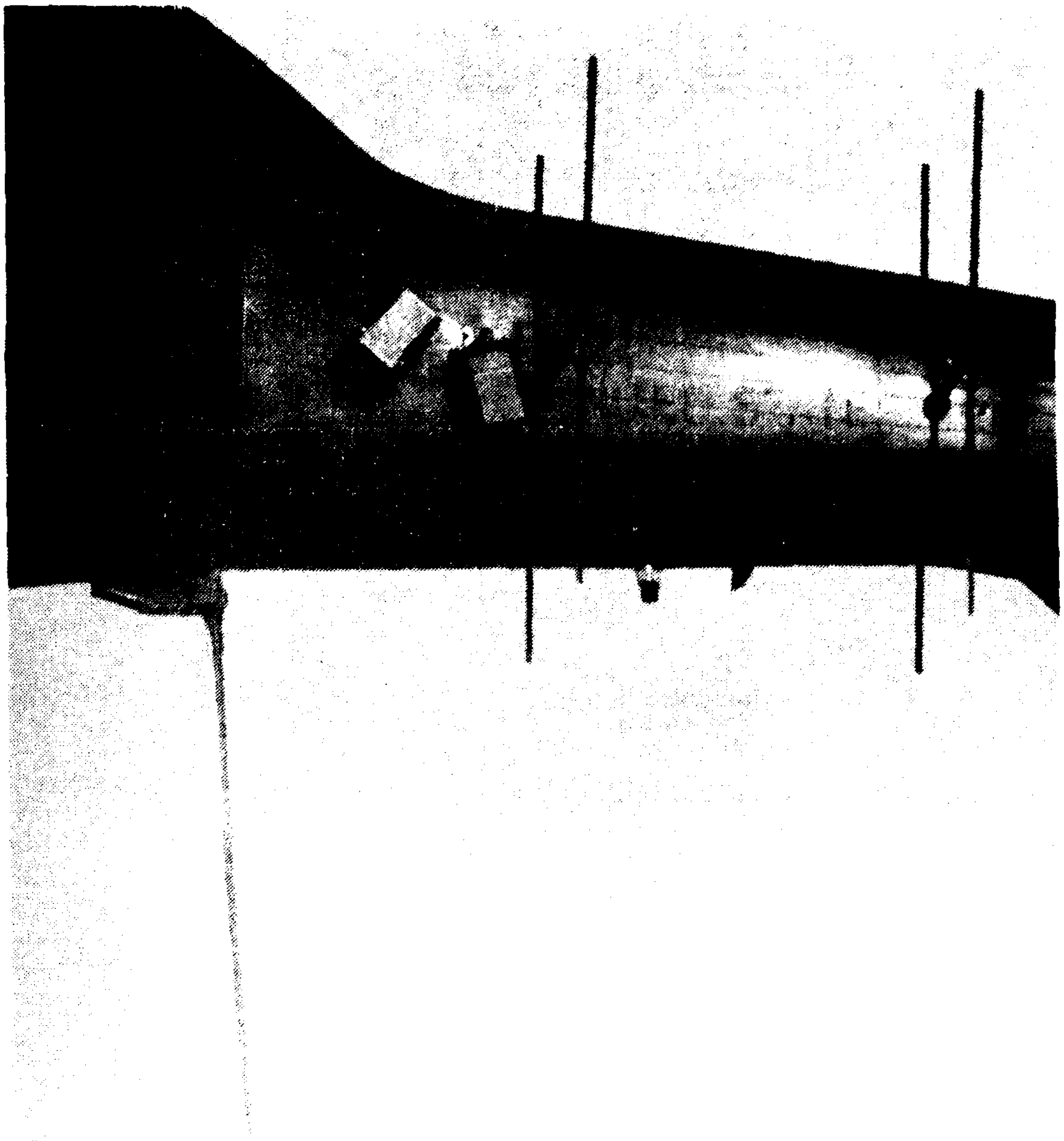


Photo 8. Electronic Countermeasure Antenna - Extended

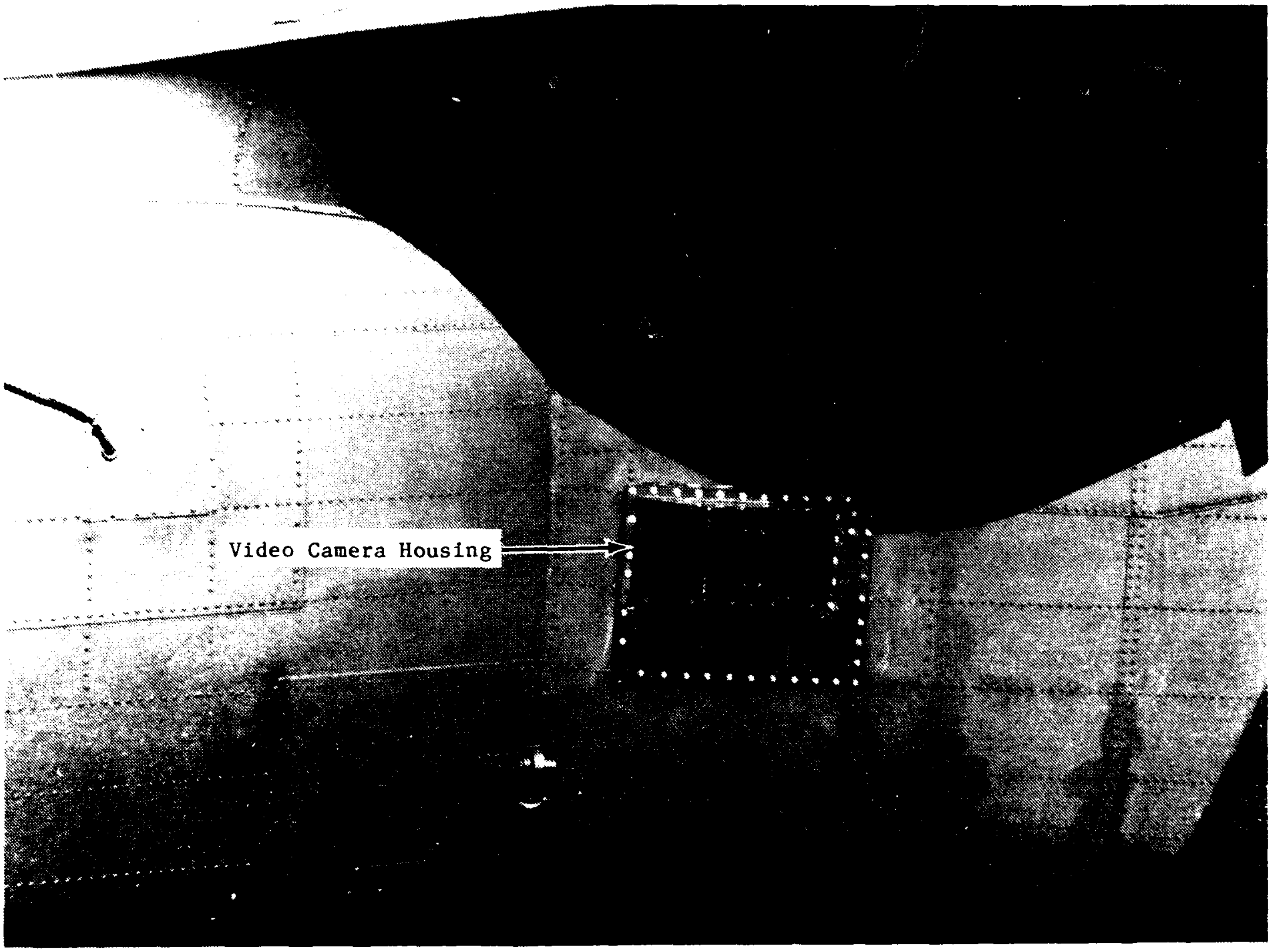


Photo 1. Direction Finding Antenna Camera

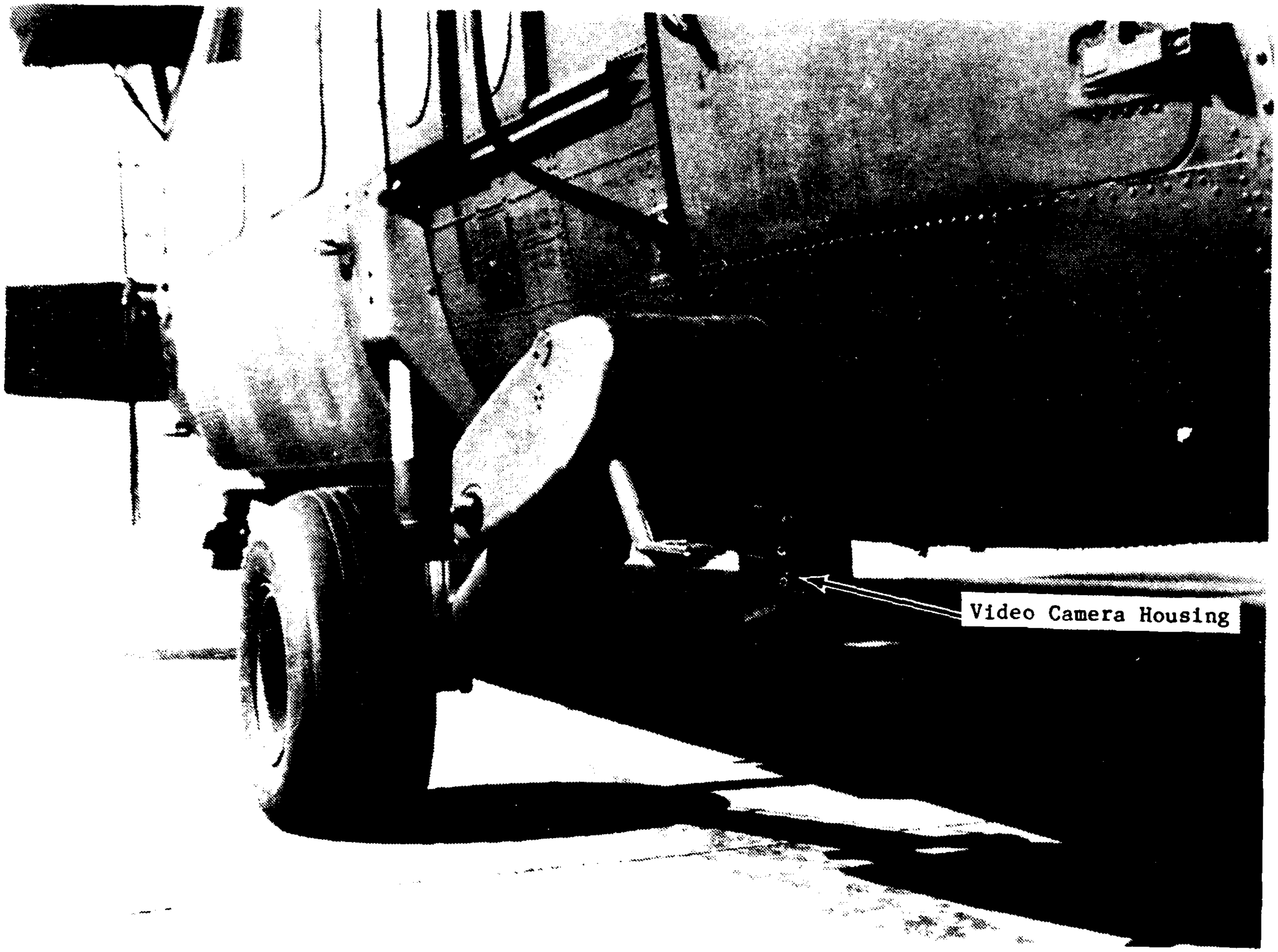


Photo 2. Electronic Countermeasure Antenna Camera

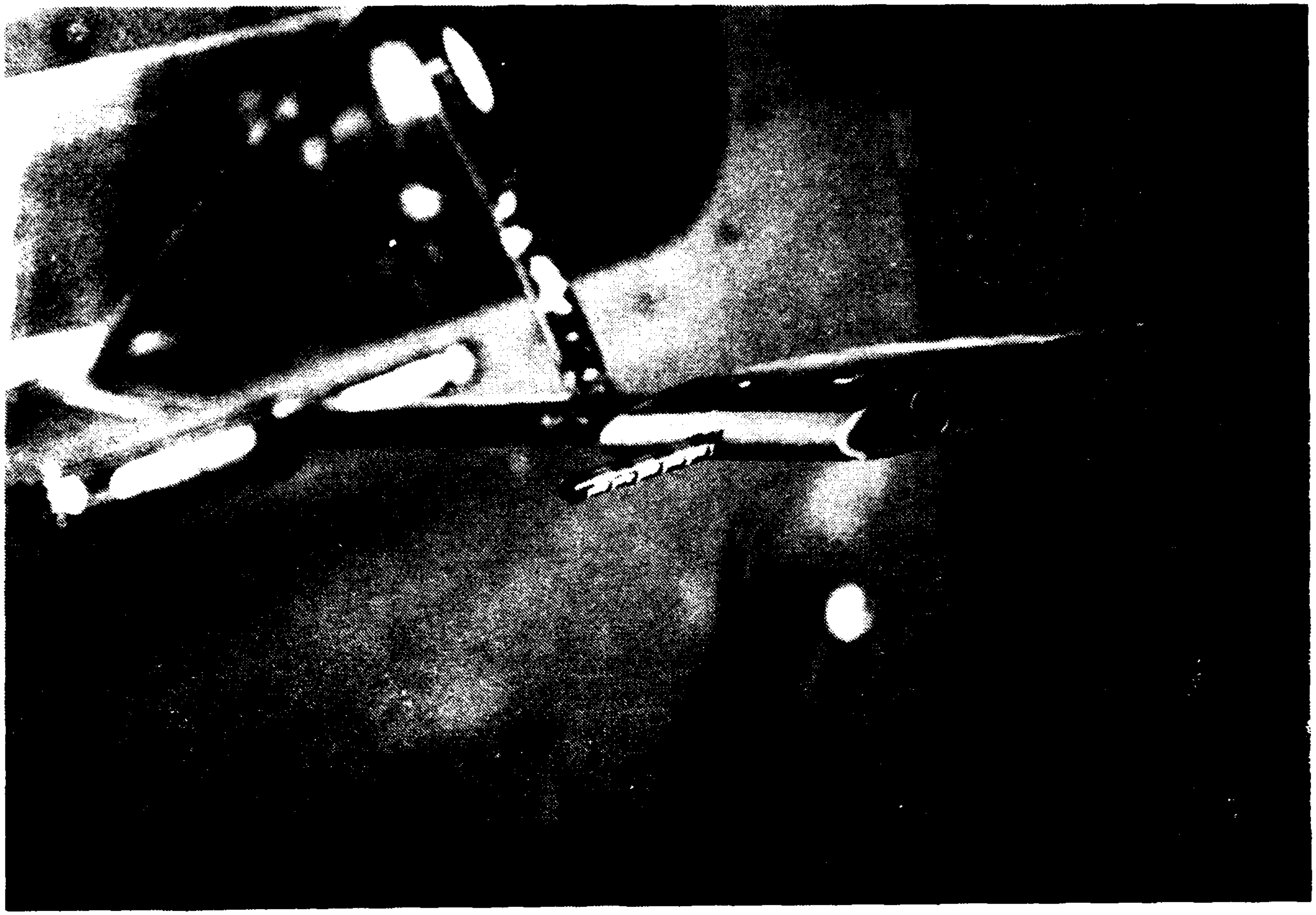


Photo 3. Visual Ice Accretion Probe

scattering spectrometer probe (model FSSP-100), a PMS optical array cloud droplet spectrometer probe (model OAP-200X), Rosemount OAT sensor and display, Cambridge model 137 chilled mirror dew point hygrometer and display, Leigh Mk 10 ice detector unit with digital display, Cloud Technology ice detector unit, and a Small Intelligent Icing Data System (SIIDS).

5. The FSSP-100 sizes particles by measuring the amount of light scattered into the collecting optics aperture during particle interaction through a focused helium-neon high order, multimode laser beam. The signal pulses are alternating current coupled to a pulse height analyzer which compares their maximum amplitude with a reference voltage derived from a separate measurement of the direct current light signal illuminating the particles. The output of the pulse height analyzer is encoded to give the particle size in binary code. The probe is set up to size particles from 2 to 47 microns having velocities between 20 and 125 m/sec (39 to 243 knots).

6. The OAP-200X sizes using a linear array of photodiodes to sense the shadowing of array elements by particles passing through its field-of-view. Particles are illuminated by a helium-neon laser and imaged as shadowgraphs on the photodiode array. If the shadowing of each photodiode element is dark enough a flip-flop element is set. The particle size is determined by the number of elements set by a particle's passage, the size of each array element, and the magnification of the optical system. This probe contains 24 active photodiode elements capable of sizing into 15 size channels with a magnification set for a size range of 20 to 300 microns.

7. The SIIDS is a compact data acquisition system designed and programmed specifically for icing studies. It consists of four main components: a microprocessor, Techtran data cassette recorder, Axiom printer, and an operator control panel. The SIIDS has three operational modes: (1) data acquisition, in which averaged raw data are recorded on cassette tape and averaged engineering units are displayed on the printer, (2) a playback mode in which raw averaged data read from the cassette are converted to average engineering units which are displayed on the printer, (3) monitor mode used to set the calendar clock and alter programmed constants. During data acquisition, the operator may select an averaging period of 1/2, 1, 2, 5, or 10 seconds.

8. The following parameters are displayed on the SIIDS printer in engineering units.

a. calendar: year, month, day, hour, minute and second

b. pressure altitude (feet)

c. airspeed (knots)

d. outside air temperature (°C)

e. dew point (°C)

f. total liquid water content observed by the FSSP (g/m^3)

g. total liquid water content observed by both the FSSP and OAP (g/m^3)

h. median volumetric diameter (μm)

i. amount of liquid water content observed for each channel (total 30) of both probes (g/m^3)

APPENDIX E. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. The production deice system on the YEH-60A helicopter was functionally tested prior to each icing flight. All anti-ice systems (pitot heat, windshield, engine, and engine inlet) and rotor deice systems were activated while enroute to the test area. A build-up program was used to gain experience with flight in icing conditions. For artificial icing the test aircraft entered the artificial spray cloud from a position below and approximately 150 feet behind the spray. Test and spray aircraft horizontal separation distance was maintained during the icing flight by observing yellow (greater than 160 feet) and red (closer than 140 feet) lights mounted on the bottom of the spray aircraft. The visual indication was supplemented as required by information relayed from the spray aircraft. Because of the limited depth of the icing cloud, the DF dipole antennas and the ECM whip antenna could not be immersed simultaneously. Information from the chase aircraft was used to position the test aircraft vertically so as to ice either the DF or ECM antenna. All artificial icing flights were flown with a predetermined liquid water content (LWC) and outside air temperature (OAT). Airspeed and OAT were established with the calibrated instrumentation of the spray aircraft. Flight continued in the cloud condition until a test aircraft limitation was reached or until the spray aircraft fuel or water limit was reached. For natural icing the JU-21A would locate and document the icing condition and radio the data to the test aircraft before it entered the icing environment. The JU-21A would then orbit in the area to facilitate a post-immersion rapid in-flight join-up with the test aircraft for photographic documentation. The LWC, particle size in the icing cloud, OAT, and relative humidity were documented by the JU-21A chase/scout aircraft configured with the particle measuring system instrumentation.

ICE ACCRETION AND SHEDDING

2. Ice accretion in the natural icing environment was determined in flight using the visual ice accretion probe indicator. The visual probe was monitored by the copilot. The Rosemount icing rate meter was used to monitor LWC.

3. Ice accretion on the test aircraft was documented using hand-held motion picture and video tape cameras photographing from both the chase aircraft and spray aircraft. Postflight photographs were made to document the ice remaining on the individual components of the airframe and rotors. A description of the camera systems is presented in appendix D.

4. Ice shedding characteristics were qualitatively assessed by crew members in the test, spray, and chase aircraft.

WEIGHT AND BALANCE

5. Prior to the test, the aircraft gross weight, longitudinal and lateral center of gravity were determined by using calibrated scales. The aircraft was weighed with instrumentation, fixed ballast and no fuel.

DEFINITIONS

6. Icing characteristics were described using the following definitions of icing severity. These definitions may be found in FM 1-30 and the UH-60A operator's manual.

a. Trace icing: Ice becomes perceptible. Rate of accumulation slightly greater than rate of sublimation. It is not hazardous even though deicing equipment is not used, unless encountered for an extended period of time (over 1 hour). Commonly 0 to 0.15 gm/m^3 LWC for the UH-60A helicopter.

b. Light icing: The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used. Commonly 0.15 to 0.5 gm/m^3 LWC for the UH-60A helicopter.

c. Moderate icing: The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary. Commonly 0.5 to 1.0 gm/m^3 LWC for the UH-60A helicopter.

d. Severe/heavy icing: The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary. Commonly greater than 1.0 gm/m^3 LWC for the UH-60A helicopter.

7. Results were categorized as deficiencies or shortcomings in accordance with the following definitions.

Deficiency: A defect or malfunction discovered during the life cycle of an item of equipment that constitutes a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability.

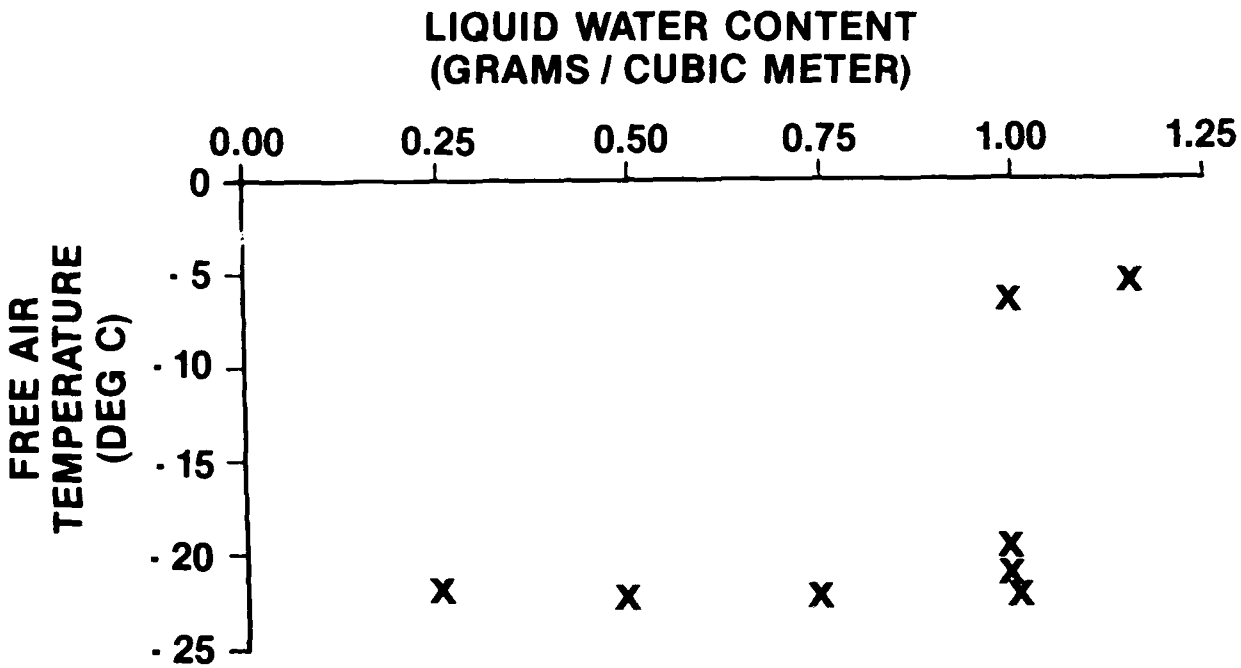
Shortcoming: An imperfection or malfunction occurring during the life cycle of equipment, which must be reported and which should be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the materiel or end product.

APPENDIX F. TEST DATA

Table 1. Specific Test Conditions[1]

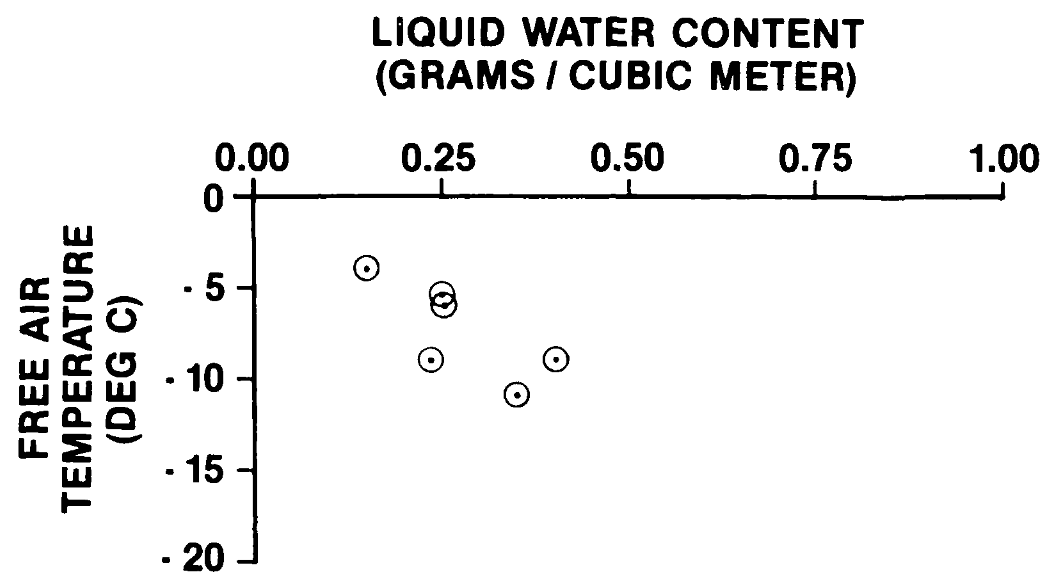
Flt No.	Environment	Configuration	Average Gross Weight (lb)	Average Longitudinal CG (FS)	Average Density Altitude (ft)	Average OAT (°C)	Average LWC (gm/m^3)	Average True Airspeed (kts)	Total Time in Cloud (min)
1	Artificial	ECM retracted	15830	361.4	6640	-20.0	1.00	116	28
2	Artificial	ECM extended	15640	360.6	2810	-21.5	1.00	123	49
4	Natural	ECM extended	15480	359.9	3630	-11.0	0.35	127	75
5	Natural	ECM retracted	15460	359.8	7630	-9.0	0.40	126	98
6	Artificial	ECM extended	15740	361.1	4700	-5.5	1.16	120	46
7	Natural	ECM extended	15410	359.4	2000 3450	-4.0 -6.0	0.15 0.26	93 95	60 19
8	Artificial	ECM retracted, Heated DF	16090	361.0	830	-22.0	0.26	120	10
10	Artificial	ECM retracted, Heated DF	16120 15910 15710	361.0 360.4 359.6	1620	-22.5	0.50 0.75 1.02	120	10 10 10
12	Natural	ECM extended, Heated DF	15530	360.1	5810	-5.5	0.25	131	69
13	Artificial	ECM retracted, Heated DF	15780	361.1	6680	-6.5	1.00	120	43
14	Natural	ECM extended, Heated DF	15370	359.4	7390	-9.0	0.23	123	62

NOTE: Main rotor speed = 258 rpm, mid lateral cg location.



NOTE: MAIN ROTOR SPEED = 258 RPM
AVERAGE GROSS WEIGHT 15,850 LB
AVERAGE LONGITUDINAL CG LOCATION = FS 360.8 (AFT)
AVERAGE DENSITY ALTITUDE = 3880 FT

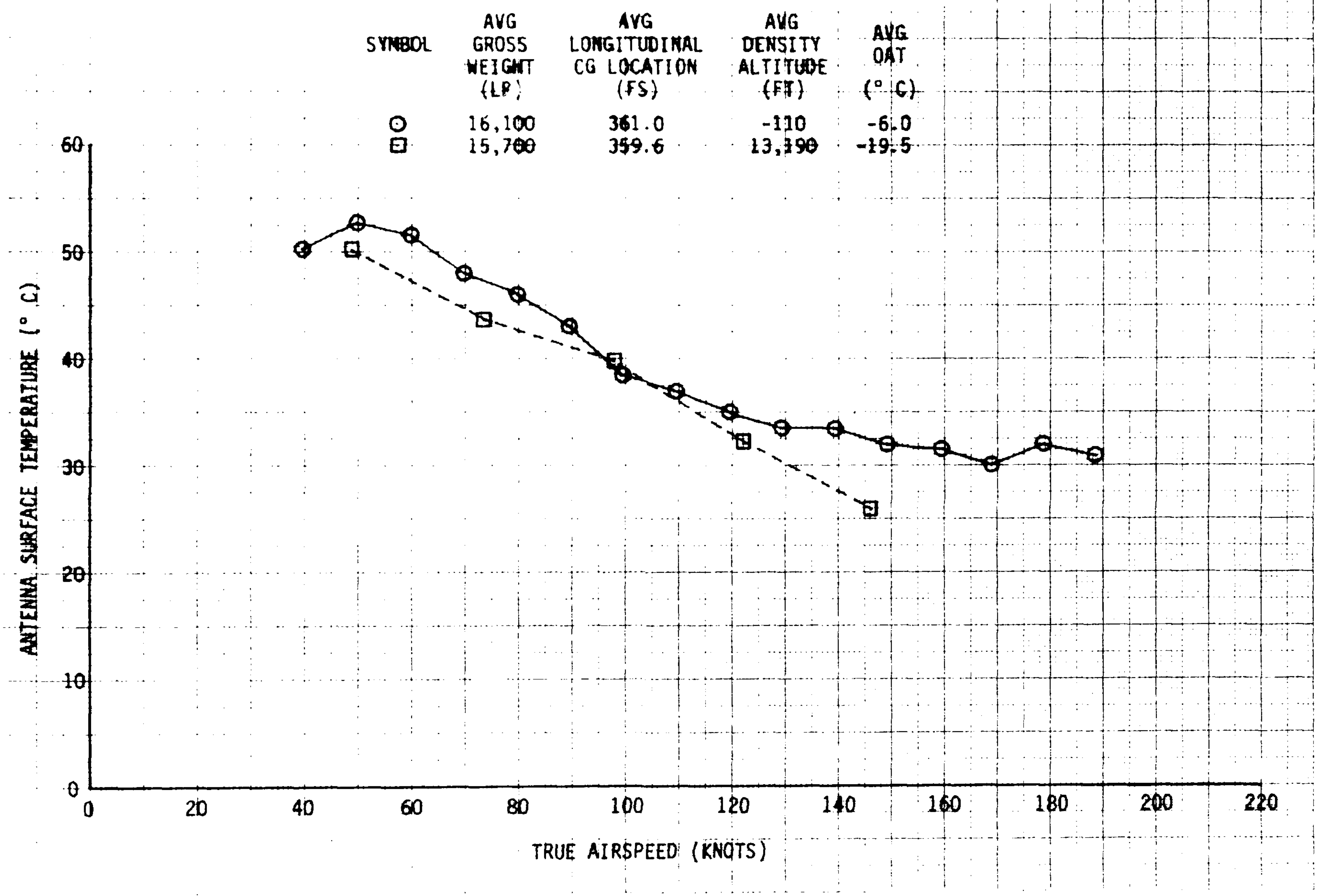
Figure 1. Artificial Icing Conditions



NOTE: MAIN ROTOR SPEED = 258 RPM
AVERAGE GROSS WEIGHT 15,450 LB
AVERAGE LONGITUDINAL CG LOCATION = FS 359.7 (AFT)
AVERAGE DENSITY ALTITUDE = 4980 FT

Figure 2. Natural Icing Conditions

QUICK FIX HEATED DIPOLE ANTENNA TEMPERATURE SURVEY
YEH-60A USA S/N 79-23301



APPENDIX G. EQUIPMENT PERFORMANCE REPORTS

The following Equipment Performance Reports (EPR's), DARCOM Form 2134, 1 September 1976, were submitted by USAAEFA during this evaluation.

EPR Number	Subject
83-21-01	Main Rotor Blade
83-21-02	Main Rotor Blade
83-21-03	DF Antenna/Main Rotor Blade Interference
83-21-04	DF Antenna Phenolic Base
83-21-05	Blade Deice Test Panel
83-21-06	Main Rotor Blade
83-21-07	Tail Rotor Tip Cap
83-21-08	Main Rotor Blade

Photo 5. Cracked Phenolic Block Unheated Direction Finding Antenna #3
Natural Icing - 0.35 gm/m^3 LWC, -21.5°C, 75 Minutes, Flt #4

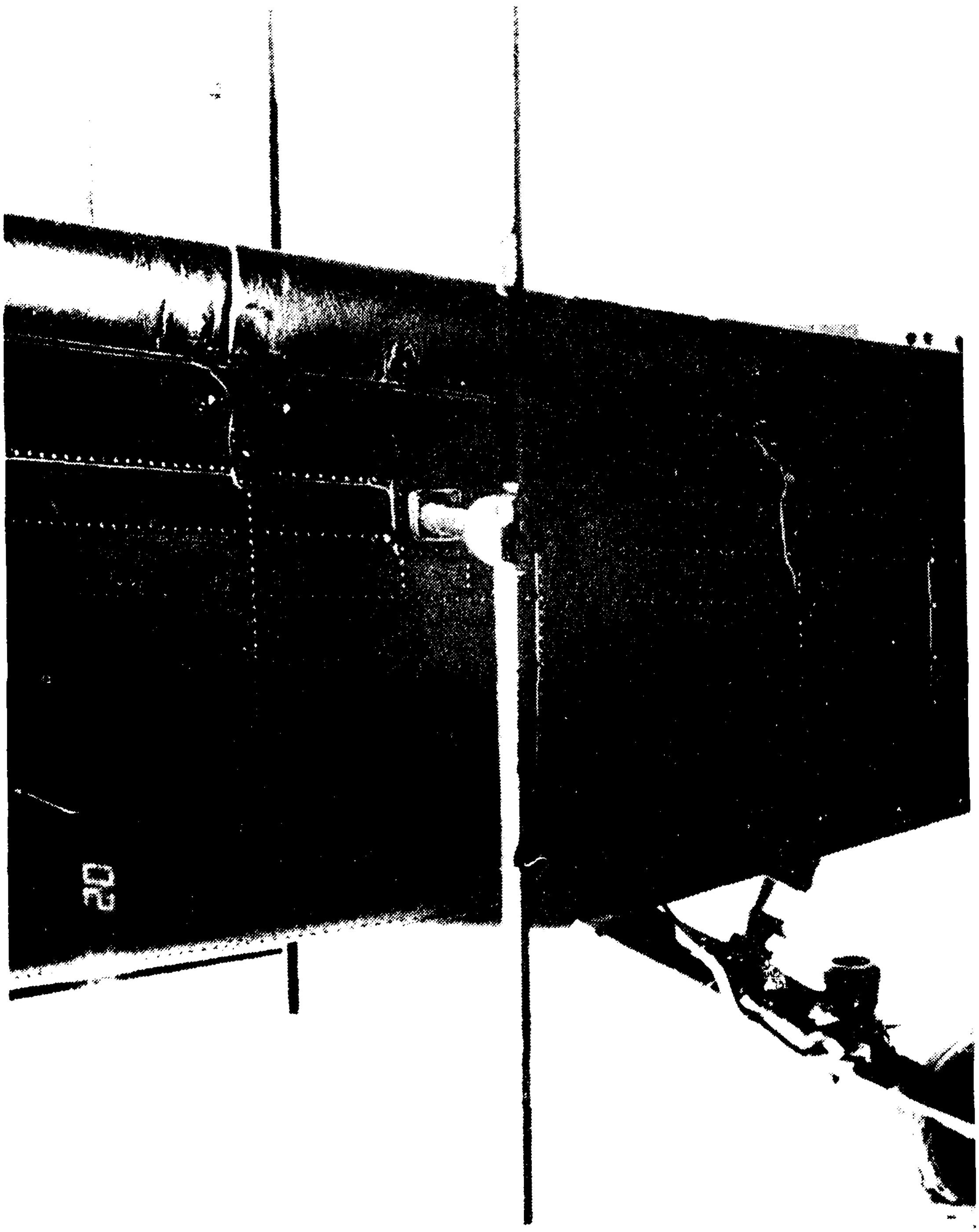


Photo 4. Ice Accretion Unheated Direction Finding Dipole Antenna - Artificial Icing - 1.0 gm/m^3 LWC, -20.0°C, 28 Minutes, Flt #1

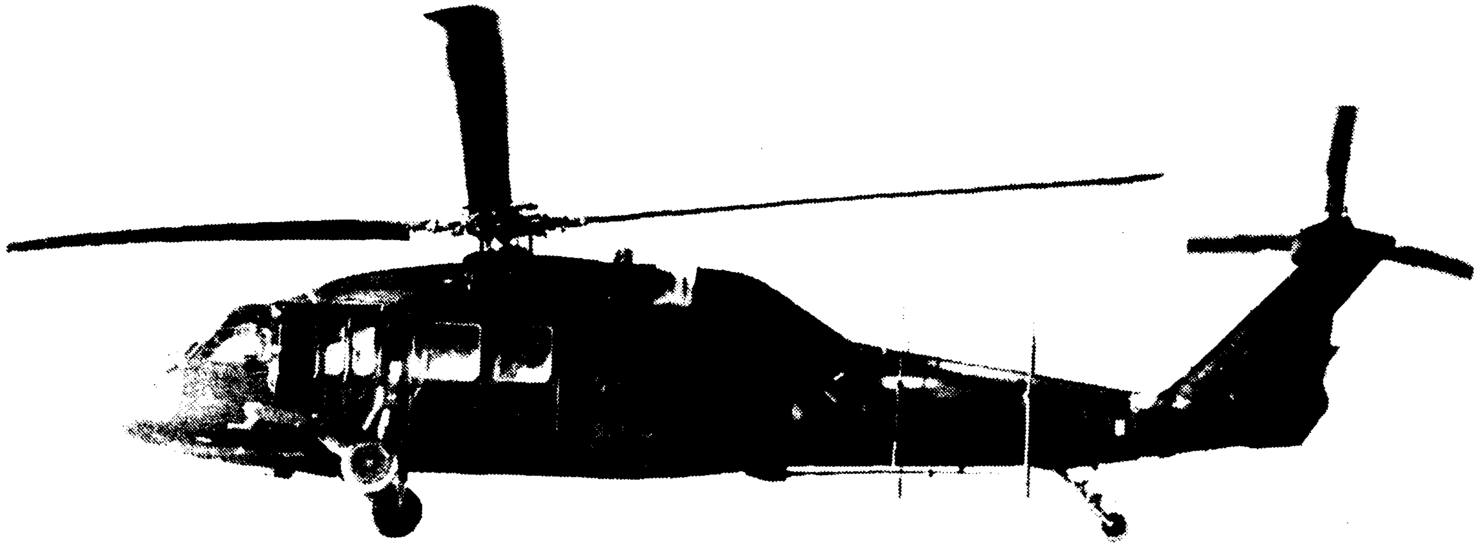


Photo 3. Airframe Ice Accretion - Artificial Icing - 1.0 gm/m3 LWC. -20.0°C, 28 Minutes. Flt #1

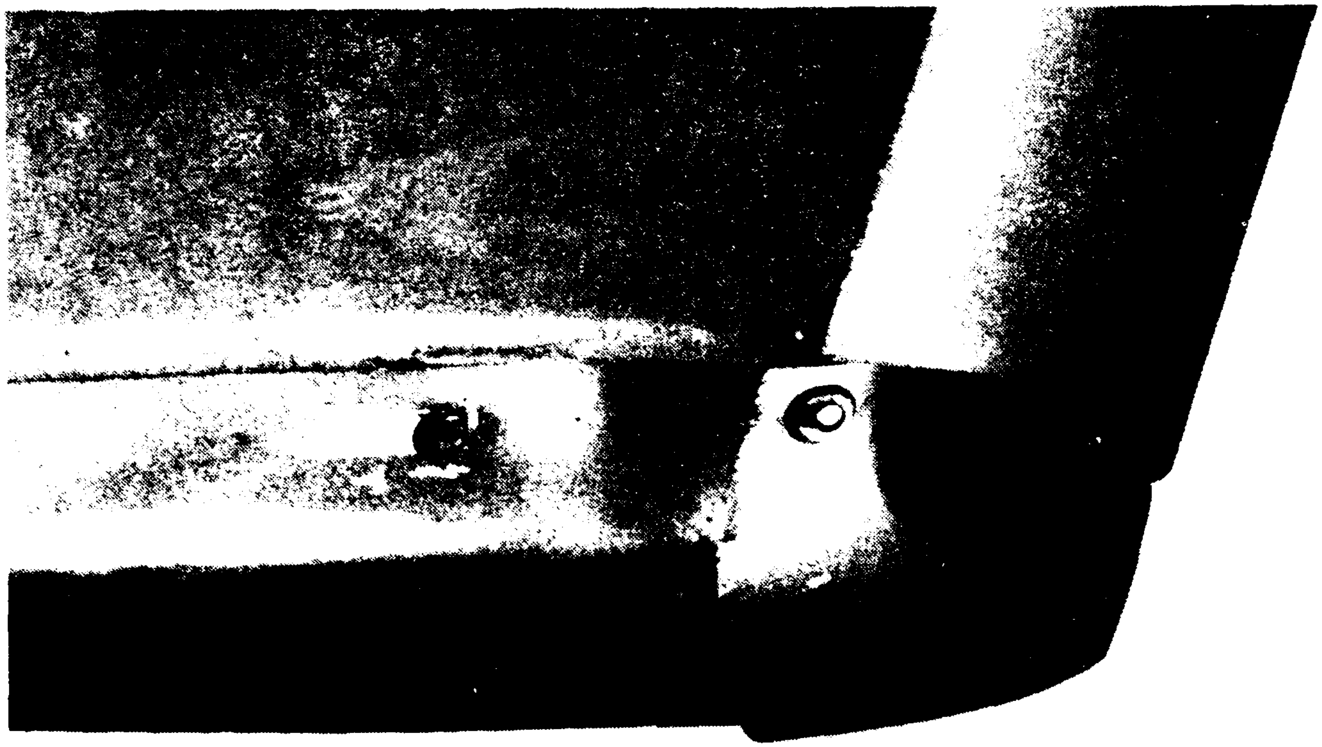


Photo 2. Tail Rotor Tip Cap Damage - Artificial Icing - 1.0 gm/m^3 LWC, -6.5°C, 43 Minutes, Flt #13

Photo 1. Ice Accretion Improved Droop Stop - Natural Icing - 1.0 gm/m^3 LWC, -20°C, 75 Minutes, Flt #4

APPENDIX H. PHOTOGRAPHS

EQUIPMENT PERFORMANCE REPORT

(DARCOM AMCR 700-38)

DATE:	23 March 1984
OFFICE SYMBOL:	SAVTE-TB

TO:	FROM:
Commander US Army Aviation Systems Command ATTN: DRSAV-EI 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	Commander US Army Aviation Engineering Flt Actv ATTN: SAVTE-TB Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-8	USAAEFA Project No. 83-21	Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY 1	7. LIFE PERIOD:
8. MFR Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Main Rotor Blade Assembly	
11. FSN 1615-01-106-1903	12. MFR PART NO.: 70150-9100-043
13. DRAWING NO.:	14. MFR: Sikorsky
15. QUANTITY 1	16. NEXT ASSEMBLY:
17. MAC FUNCTIONAL GRP:	18. PART TEST LIFE: Condition

III INCIDENT DATA

19. DATE OF OCCURRENCE: 8 March 1984		20. TYPE OF REPORT:		21. ACTION TAKEN:	
22. MAINT SPT. ELM. CODE:		X	a. INCIDENT	X	a. REPLACED
23. OBSERVED DURING	24. TEST ENVIRONMENT		b. INFORMATION		b. REPAIRED
a. OPERATION	Post-Flight Inspection -18° C	25. INCIDENT CLASSIFICATION:			c. ADJUSTED
b. MAINTENANCE			a. CRITICAL		d. DISCONNECTED
c. INSPECTION		X	b. MAJOR		e. REMOVED
d. OTHER			c. MINOR		f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

Blade (S/N A007-02258) was new ("0" time) when installed and had been on the aircraft 41 flight hours. On the day of the incident, the aircraft had flown 0.9 hours behind the Helicopter Icing Spray System (HISS) at -20° C (4500 ft PA). Aircraft was placed in a -16 hangar for deicing between HISS flights. During pre-flight inspection, blue blade BIM was showing partial "RED" (failed). Inspection showed BIM was loose. BIM was tightened and blade reserviced. Aircraft then was flown an additional 1.4 hours behind the HISS. Post-flight inspection following the flight showed the BIM indicated "RED" (failed). Blade was replaced.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. ... MATERIAL SENT TO

28. NAME, TITLE & TELEPHONE OF PREPARER	29. FOR THE COMMANDER
EDWARD T. TAVARES, MAJ, AV Project Officer USAAEFA Project No. 83-21	CPT, AV FOR RANDALL G. OLIVER, MAJ, AV Chief, Plans & Programs

DARCOM ... 2134 Previous edition may be used until exhausted.

EQUIPMENT PERFORMANCE REPORT
(DARCOM AMCR 700-38)

DATE:

OFFICE SYMBOL: SAVTE-TB

TO	FROM
Commander US Army Aviation Systems Command ATTN: DRSAV-EI 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	Commander US Army Aviation Engineering Flt Actv ATTN: SAVTE-TB Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-7	USAAEFA Project No. 83-21	Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL: YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY: 1	7. LIFE PERIOD:
8. MFR: Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Cap Assembly Tip (Tail Rotor)

11. FSN: 1615-01-130-1469	12. MFR PART NO.: S0101-31131-041
13. DRAWING NO.:	14. MFR:
15. QUANTITY:	16. NEXT ASSEMBLY: Tail Rotor Paddle
17. MAC FUNCTIONAL GRP:	18. PART TEST LIFE: Condition

III INCIDENT DATA

19. DATE OF OCCURRENCE: 16 March 1984

22. MAINT SPT, ELM, CODE:

23. OBSERVED DURING:	24. TEST ENVIRONMENT:
a. OPERATION	DA 6680 FT
b. MAINTENANCE	OAT -6.5° C
c. INSPECTION	LWC 1.0 gm/m³
d. OTHER	

20. TYPE OF REPORT:		21. ACTION TAKEN:	
X	a. INCIDENT		a. REPLACED
	b. INFORMATION	X	b. REPAIRED
25. INCIDENT CLASSIFICATION:			c. ADJUSTED
	a. CRITICAL		d. DISCONNECTED
	b. MAJOR		e. REMOVED
X	c. MINOR		f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

On 16 March 1984, aircraft was flown behind the Helicopter Icing Spray System for 43 minutes. Flight was flown at a density altitude of 6680 FT, an OAT of -6.5° C with a Liquid Water Content of 1.0 gm/m³. Post flight inspection showed that one of the tail rotor blade tip caps had been dented by ice. One of the front retaining rivets had pulled through. Maintenance personnel were able to repair the damage without replacing the tail rotor blade.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO:

28. NAME, TITLE & TEL EXT OF PREPARER:	29. FOR THE COMMANDER:
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project No. 83-21	RANDALL G. OLIVER, MAJ, AV Chief, Plans & Programs

DARCOM FORM 1 SEP 76 2134 *Previous edition may be used until exhausted.*

EQUIPMENT PERFORMANCE REPORT
(DARCOM AMCR 700-38)

DATE.

OFFICE SYMBOL: SAVTE-TB

TO	FROM
Commander US Army Aviation Systems Command ATTN: DRSAV-EI 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	Commander US Army Aviation Engineering Flt Actv ATTN: SAVTE-TB Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-6	USAAEFA Project No. 83-21	Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY 1	7. LIFE PERIOD:
8. MFR Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Main Rotor Blade Assembly	
11. FSN: 1615-01-106-1903	12. MFR PART NO.: 70150-9100-043
13. DRAWING NO.:	14. MFR: Sikorsky
15. QUANTITY: 1	16. NEXT ASSEMBLY:
17. MAC FUNCTIONAL GRP:	18. PART TEST LIFE: Condition

III INCIDENT DATA

19. DATE OF OCCURRENCE: 16 March 1984

22. MAINT SPT. ELM. CODE:

23. OBSERVED DURING
- a. OPERATION
- b. MAINTENANCE
- X c. INSPECTION
- d. OTHER

24. TEST ENVIRONMENT: Evening Post Flight Inspection

20. TYPE OF REPORT:
- X a. INCIDENT
- b. INFORMATION

25. INCIDENT CLASSIFICATION:
- a. CRITICAL
- X b. MAJOR
- c. MINOR

21. ACTION TAKEN:
- X a. REPLACED
- b. REPAIRED
- c. ADJUSTED
- d. DISCONNECTED
- e. REMOVED
- f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

Blade was installed on 18 February 1984, tracked, and test-flown (0.3 hrs). Aircraft was flown 1.2 hours on 20 February 1984. Post flight inspection of the aircraft immediately after flight revealed no probelms. However, after the aircraft was hangared for approximately 1 hour, the BIM on the blade indicated "RED" (failed). A new BIM indicator and a new "O" ring were installed. After 30 minute ground run (at 0° C), BIM indicated "YELLOW" (serviceable). After a second 30 minute ground run, BIM still indicated "YELLOW". Post ground run pressure check was also within limits. Aircraft was again placed in hangar. When blade was rechecked 2 hours later, the BIM indicated "RED".

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO:

28. NAME, TITLE & TEL EXT OF PREPARER:	29. FOR THE COMMANDER:
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project No. 83-21 AV 350-4784	RANDALL G. OLIVER, MAJ, AV Chief, Plans & Programs

DARCOM FORM 2134, 1 SEP 76 *Previous edition may be used until exhausted.*

EQUIPMENT PERFORMANCE REPORT (DARCOM AMCR 700-38)	DATE: 21 February 1984
	OFFICE SYMBOL: SAVTE-TB

TO: Commander US Army Aviation Systems Command ATTN: DRSAV-ED 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	FROM: Commander US Army Aviation Engr Flt Actv ATTN: SAVTE-TB Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-05	USAAEFA Project No. 83-21	Artificial & Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL	YEH-60A	5. SERIAL NO.	79-23301
6. QUANTITY	1	7. LIFE PERIOD	
8. MFR	Sikorsky	9. USA NO.	

II PART DATA

10. NOMENCLATURE DESCRIPTION:	Rosemount Icing Rate Indicator		
11. FSN:		12. MFR PART NO.:	70550-01124-102
13. DRAWING NO.:		14. MFR:	Rosemount
15. QUANTITY:		16. NEXT ASSEMBLY:	
17. MAC FUNCTIONAL GRP		18. PART TEST LIFE:	

III INCIDENT DATA

19. DATE OF OCCURRENCE: 31 January 1984		20. TYPE OF REPORT:	21. ACTION TAKEN:
22. MAINT SPT. ELM. CODE:		X a. INCIDENT	X a. REPLACED
23. OBSERVED DURING	24. TEST ENVIRONMENT	b. INFORMATION	b. REPAIRED
X a. OPERATION	-5° C Ground Run	25. INCIDENT CLASSIFICATION:	c. ADJUSTED
b. MAINTENANCE		a. CRITICAL	d. DISCONNECTED
c. INSPECTION		b. MAJOR	e. REMOVED
d. OTHER		X c. MINOR	f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

Incident occurred during 7-day ground run. Icing rate meter passed the functional pre-flight test (8-25, 026.a, pg 8-8 TM 55-1520-237-10). All tests of the BLADE DEICE TEST panel with rotors static (and blade deice POWER switch OFF) was successful (8-25, 026.d, -s). However, as soon as the POWER switch on the BLADE DEICE TEST panel was moved to the ON position during the DEICE EOT check (8-26, 02a.c), the DEICE CNTRLR circuit breaker (located on the No. 1 Circuit Breaker Panel for the YEH-60A) popped. The Rosemount Icing Rate Indicator (S/N 0232) was removed and a new indicator installed. After installation of a new Icing Rate Indicator, all blade deice tests were successfully completed.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO:

28. NAME, TITLE & TEL EXT OF PREPARER	29. FOR THE COMMANDER
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project No. 83-21 Ext. 4784	RANDALL G. OLIVER, MAJ Chief, Plans & Programs

DARCOM FORM 2134 *Previous edition may be used until exhausted.*

EQUIPMENT PERFORMANCE REPORT (DARCOM AMCR 700-38)	DATE: 2 February 1984
	OFFICE SYMBOL: SAVTE-TB

TO:	FROM:
Commander US Army Aviation Systems Command ATTN: DRSAV-ED 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	Commander US Army Aviation Engineering Flt Actv ATTN: SAVTE-TB, Stop 217 Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-4	USAAEFA Project No. 83-21	Artificial & Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL: YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY: 1	7. LIFE PERIOD:
8. MFR: Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Antenna DF	
11. FSN	12. MFR PART NO.: C 50 74121-2/3
13. DRAWING NO.:	14. MFR:
15. QUANTITY: 2	16. NEXT ASSEMBLY:
17. MAC FUNCTIONAL GRP	18. PART TEST LIFE:

III INCIDENT DATA

19. DATE OF OCCURRENCE: 23 January 1984		20. TYPE OF REPORT:	21. ACTION TAKEN:
22. MAINT SPT. ELM. CODE:		X a. INCIDENT	X a. REPLACED
23. OBSERVED DURING	24. TEST ENVIRONMENT	b. INFORMATION	b. REPAIRED
X a. OPERATION	Flying 5000 FT 120 KIAS, Natural Icing (LWC .30-.40)	25. INCIDENT CLASSIFICATION:	c. ADJUSTED
b. MAINTENANCE		X a. CRITICAL	d. DISCONNECTED
c. INSPECTION		b. MAJOR	e. REMOVED
d. OTHER		c. MINOR	f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

Helicopter was flown in natural icing conditions on 23 January 1984. Total time in the icing cloud was 74 minutes. Airspeed was 120 KIAS (127 KTAS). Vibrations of approximately ±4" were monitored on #2 and #3 antennae elements in flight. Vibrations began within 5 minutes of entering icing conditions. Upon landing, 1-3/4 inches of ice remained on sections of the antennae elements. Post-flight inspection showed that the phenolic base plate of antenna #2 had cracked at the upper antenna element attachment point. One of the four attachment screws for the upper element was missing. The remaining attachment screws on antennae #2 and #3 had loosened. No damage or loosening of attachment screws was evident on antennae #1 and #4 although large amplitude oscillations were observed similar to that of antenna elements #2 and #3.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO:

28. NAME, TITLE & TEL EXT OF PREPARER:	29. FOR THE COMMANDER:
EDWARD J. TAVARES, MAJ Project Officer, 8474 USAAEFA, Project No. 83-21	RANDALL G. OLIVER, MAJ, AV Chief, Plans & Programs Randall G Oliver

DARCOM FORM 2134 · *Previous edition may be used until exhausted.*

EQUIPMENT PERFORMANCE REPORT (DARCOM AMCR 700-38)	DATE: 19 January 1984
	OFFICE SYMBOL: SAVTE-TB

TO:	FROM:
Commander US Army Aviation Systems Command Attn: 4300 Goodfellow Blvd., St. Louis, MO 63120	Commander US Army Aviation Engineering Flight Actv Attn: SAVTE-TB Edwards AFB, CA 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-03	USAAEFA Project No. 83-21	Artificial & Natural Icing Tests YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY: 1	7. LIFE PERIOD:
8. MFR: Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Antenna DF	
11. FSN:	12. MFR PART NO.: C50 74121-3/4
13. DRAWING NO.:	14. MFR:
15. QUANTITY: 2	16. NEXT ASSEMBLY:
17. MAC FUNCTIONAL GRP:	18. PART TEST LIFE:

III INCIDENT DATA

19. DATE OF OCCURRENCE: 19 JAN 84

22. MAINT SPT, ELM, CODE:

23. OBSERVED DURING		24. TEST ENVIRONMENT	20. TYPE OF REPORT:		21. ACTION TAKEN:	
X	a. OPERATION	Ground Taxi Operation	X	a. INCIDENT	X	a. REPLACED
	b. MAINTENANCE	Temp 15°F (-25°C)		b. INFORMATION		b. REPAIRED
	c. INSPECTION	Winds 15 Kts Gusting	25. INCIDENT CLASSIFICATION:			c. ADJUSTED
	d. OTHER	to 25 Kts	X	a. CRITICAL		d. DISCONNECTED
				b. MAJOR		e. REMOVED
				c. MINOR		f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

After ground tracking operations, aircraft was being ground taxied rearward at slow rate. Winds were almost directly off the aircraft nose. Tail wheel was unlocked. After moving rearward 100 ft, the tail wheel rotated 180°. Pilot had applied approximately 1.5 inches of aft cyclic. Collective was approximately 3 inches from full down. A shudder was felt in the cockpit and crew chief called out that the main rotor blades had contacted both aft (#3 and #4) DF antennae elements (C5074125-1). Aircraft was shut down. Inspection showed 2 inches had been removed from the top of each element. Antennae bases were also cracked. One 2-inch antenna fragment had passed through tail rotor drive shaft cover and was found under the drive shaft. Tail rotor drive shaft was not damaged. Leading edge of main rotor blade was paint streaked, but not damaged. No other damage to drive components was noted.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO:

28. NAME, TITLE & TEL EXT OF PREPARER:	29. FOR THE COMMANDER:
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project 83-21	RANDALL G. OLIVER, MAJ, AV Chief, Plans and Programs Randall G Oliver

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EQUIPMENT PERFORMANCE REPORT (DARCOM AMCR 700-38)	DATE: 19 January 1984 / OFFICE SYMBOL: SAVTE-TB
TO: Commander US Army Aviation Systems Command ATTN: DRSAV-ED 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	FROM: Commander US Army Aviation Engineering Flight Actv ATTN: SAVTE-TB, Stop 217 Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-02	USAAEFA Project No. 83-21	Artificial and Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL YEH-60A	5. SERIAL NO. 79-23301
6. QUANTITY	7. LIFE PERIOD:
8. MFR Sikorsky	9. USA NO.:

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Main Rotor Blade Assembly	
11. FSN 1615-01-106-1903	12. MFR PART NO.: 70150-09100-043
13. DRAWING NO.	14. MFR: Sikorsky
15. QUANTITY 1	16. NEXT ASSEMBLY:
17. MAC FUNCTIONAL GRP	18. PART TEST LIFE: Cond

III INCIDENT DATA

19. DATE OF OCCURRENCE: 10 January 1984		20. TYPE OF REPORT:		21. ACTION TAKEN:	
22. MAINT SPT. ELM. CODE:		X	a. INCIDENT	X	a. REPLACED
23. OCCURRED DURING	24. TEST ENVIRONMENT		b. INFORMATION		b. REPAIRED
a. OPERATION	After ground run and OGE for blade tracking Temp -15° F (-26° C)	25. INCIDENT CLASSIFICATION:			c. ADJUSTED
b. MAINTENANCE			a. CRITICAL		d. DISCONNECTED
c. INSPECTION		X	b. MAJOR		e. REMOVED
d. OTHER			c. MINOR		f. NONE

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY. INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

BIM on blue main rotor blade S/N A007-02314 indicated "RED" (failed) when inspected following approximately 20 minutes of ground tracking and OGE hover tracking in extremely cold conditions. Blade had "0" time when installed and 20 minutes at failure.

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. EXHIBIT OR MATERIAL SENT TO

28. NAME, TITLE & TEL EXT OF PREPARER	29. FOR THE COMMANDER:
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project No. 83-21 EXT 4784	RANDALL G. OLIVER, MAJ Chief, Plans & Programs

DARCOM FORM 2134

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EQUIPMENT PERFORMANCE REPORT
(DARCOM AMCR 700-38)

DATE: 19 January 1984

OFFICE SYMBOL: SAVTE-TB

TO:	FROM:
Commander US Army Aviation Systems Command ATTN: DRSAV-ED 4300 Goodfellow Boulevard Saint Louis, Missouri 63120	Commander US Army Aviation Engineering Flight Actv ATTN: SAVTE-TB, Stop 217 Edwards AFB, California 93523

1. EPR NO.:	2. TECOM/AVSCOM PROJ NO.:	3. TEST TITLE
83-21-01	USAAEFA Project No. 83-21	Artificial & Natural Icing Tests, YEH-60A Quick Fix Helicopter

I MAJOR ITEM DATA

4. MODEL	YEH-60A	5. SERIAL NO	79-23301
6. QUANTITY:	1	7. LIFE PERIOD:	
8. MFR:	Sikorsky	9. USA NO.:	

II PART DATA

10. NOMENCLATURE/DESCRIPTION: Main Rotor Blade Assembly

11. FSN:	1615-01-106-1903	12. MFR PART NO.:	70150-09100-043
13. DRAWING NO.:		14. MFR:	Sikorsky
15. QUANTITY:	1	16. NEXT ASSEMBLY:	
17. MAC FUNCTIONAL GRP:		18. PART TEST LIFE:	Cond

III INCIDENT DATA

19. DATE OF OCCURRENCE: 19 January 1984

22. MAINT SPT, ELM, CODE:

20. TYPE OF REPORT:		21. ACTION TAKEN	
X	a. INCIDENT	X	a. REPLACED
	b. INFORMATION		b. REPAIRED
			c. ADJUSTED
			d. DISCONNECTED
			e. REMOVED
			f. NONE

23. OBSERVED DURING		24. TEST ENVIRONMENT:
	a. OPERATION	Morning Pre-Flight Inspection
	b. MAINTENANCE	
X	c. INSPECTION	
	d. OTHER	

25. INCIDENT CLASSIFICATION:	
	a. CRITICAL
X	b. MAJOR
	c. MINOR

IV INCIDENT DESCRIPTION

26. DESCRIBE INCIDENT FULLY (INCLUDE IMPACT OF INCIDENT ON MAC CODE IDENTIFIED IN BLOCK 22):

BIM on blue main rotor blade indicated "RED" (failed) when checked during daily inspection. Aircraft had been in hangar overnight when condition noted. Blue blade (S/N A007-02258) had 23.1 total time since installed. Blade was reserviced and ground-checked. After first 30 minute ground run (at -15° F OAT), BIM still indicated yellow. Upon completion of second 30 minute ground run, BIM again indicated "RED" (failed).

INCIDENT CLASSIFICATION IS SUBJECT TO RECLASSIFICATION

27. DEFECTIVE MATERIAL SENT TO

28. NAME, TITLE & TEL EXT OF PREPARER	29. FOR THE COMMANDER
EDWARD J. TAVARES, MAJ Project Officer USAAEFA Project No. 83-21 EXT 4784	RANDALL G. OLIVER, MAJ Chief, Plans & Programs

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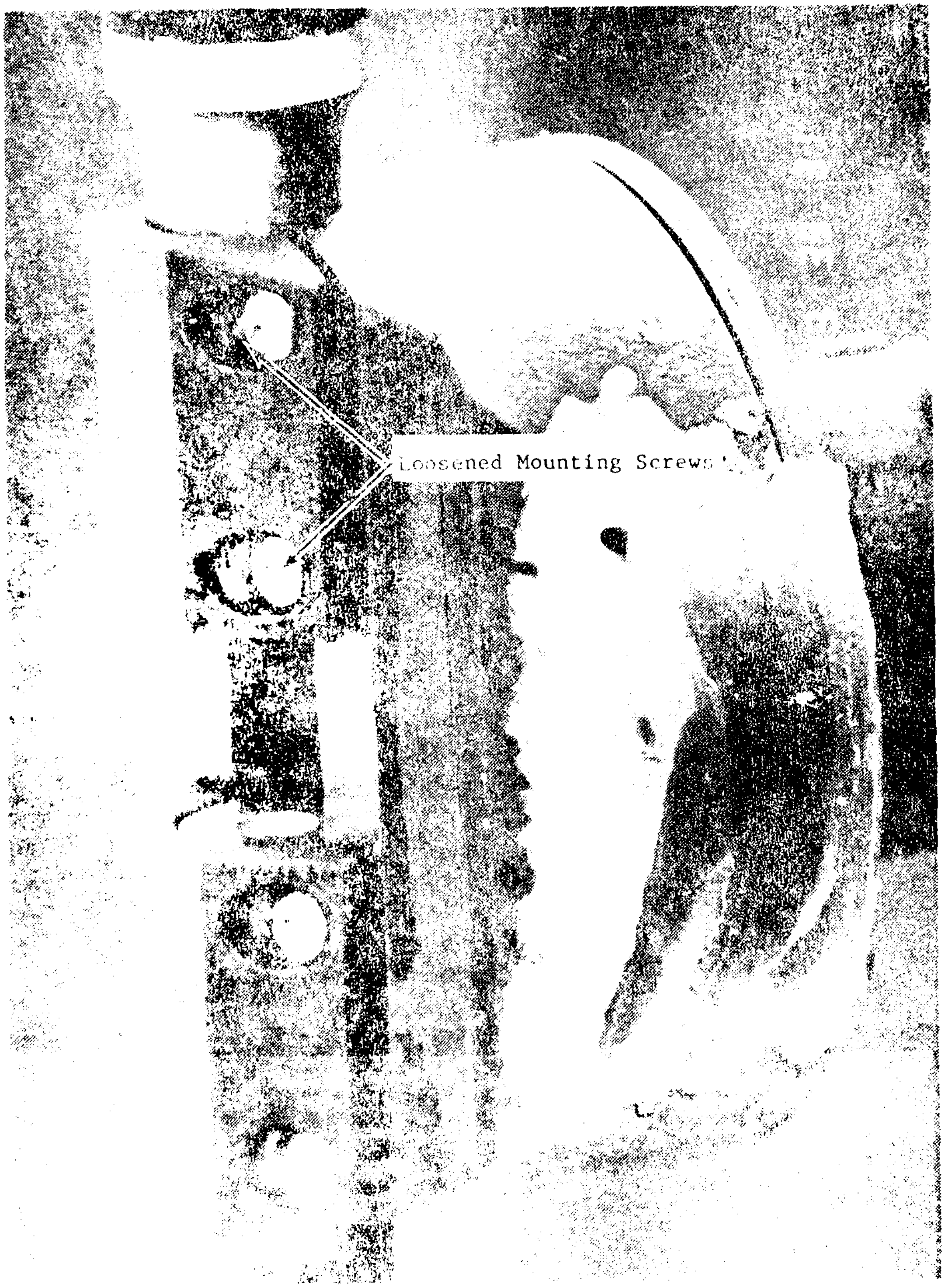

[illegible] — Natural [illegible]
75 Min[illegible]

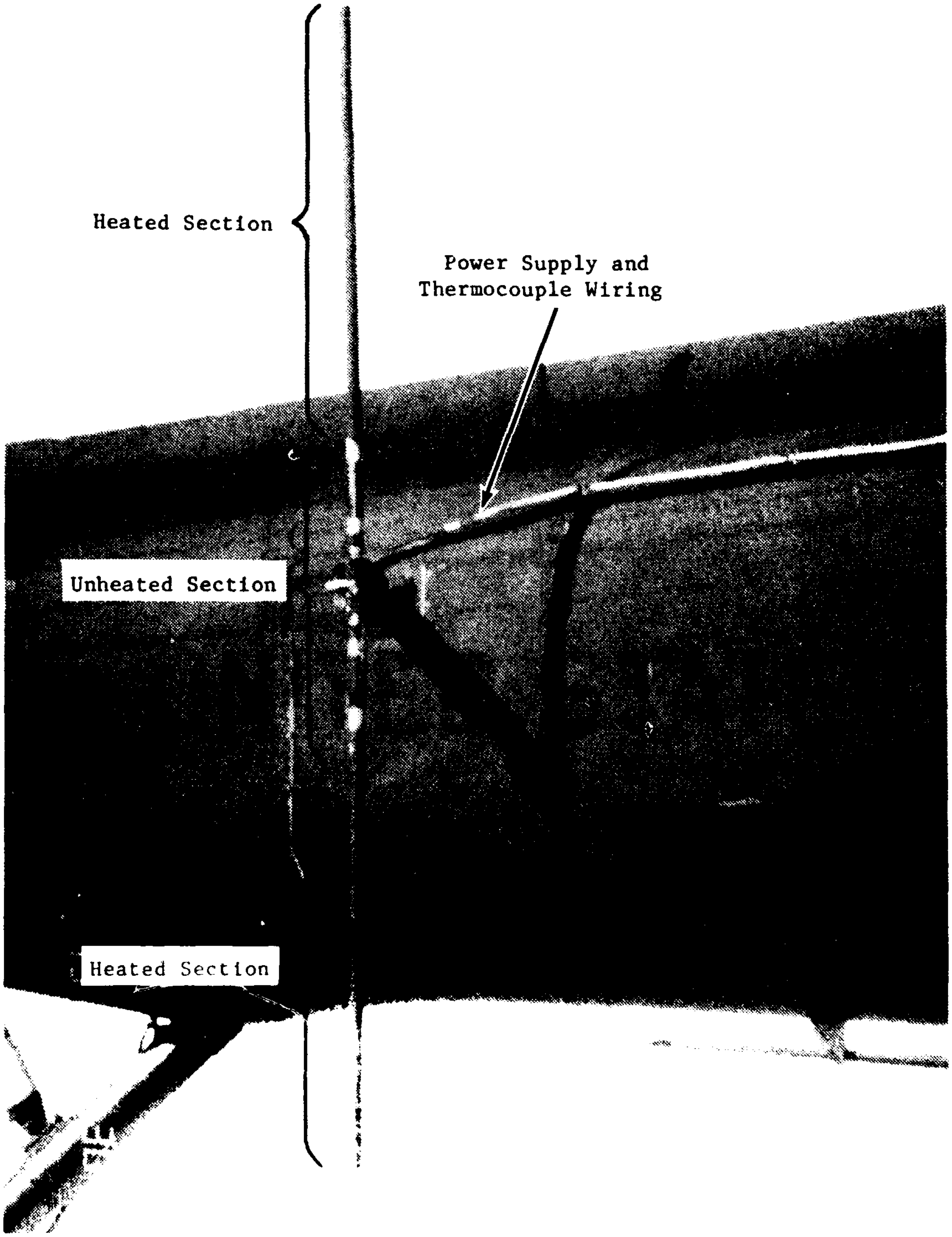

Photo 7. Heated Direction Finding Dipole Antenna #3

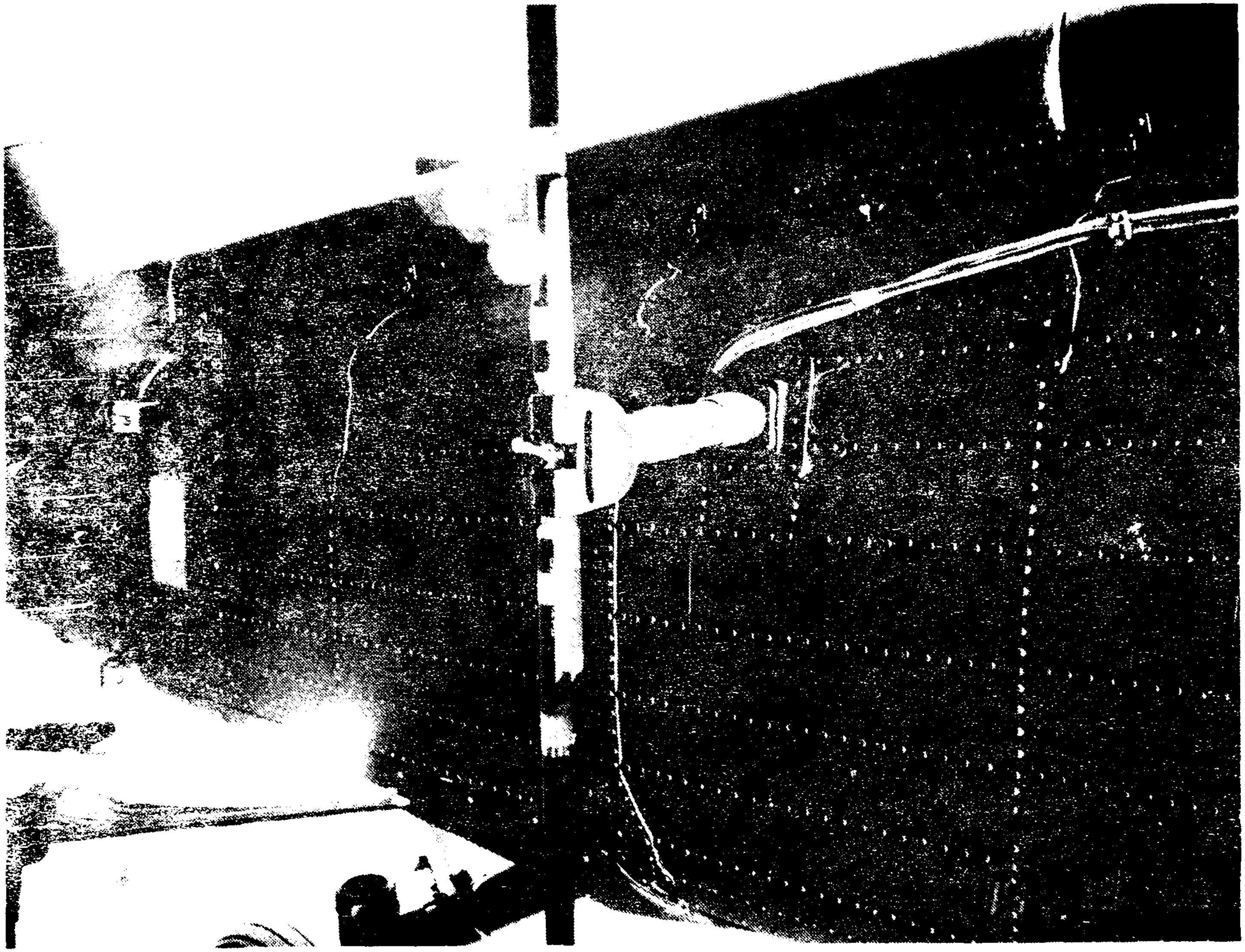

Photo 8. Ice Accretion on Unprotected Sections of Heated Direction Finding Dipole Antenna - Artificial Icing - 1.0 gm/m^3 LWC, -6.5°C, 43 Minutes, Flt #13

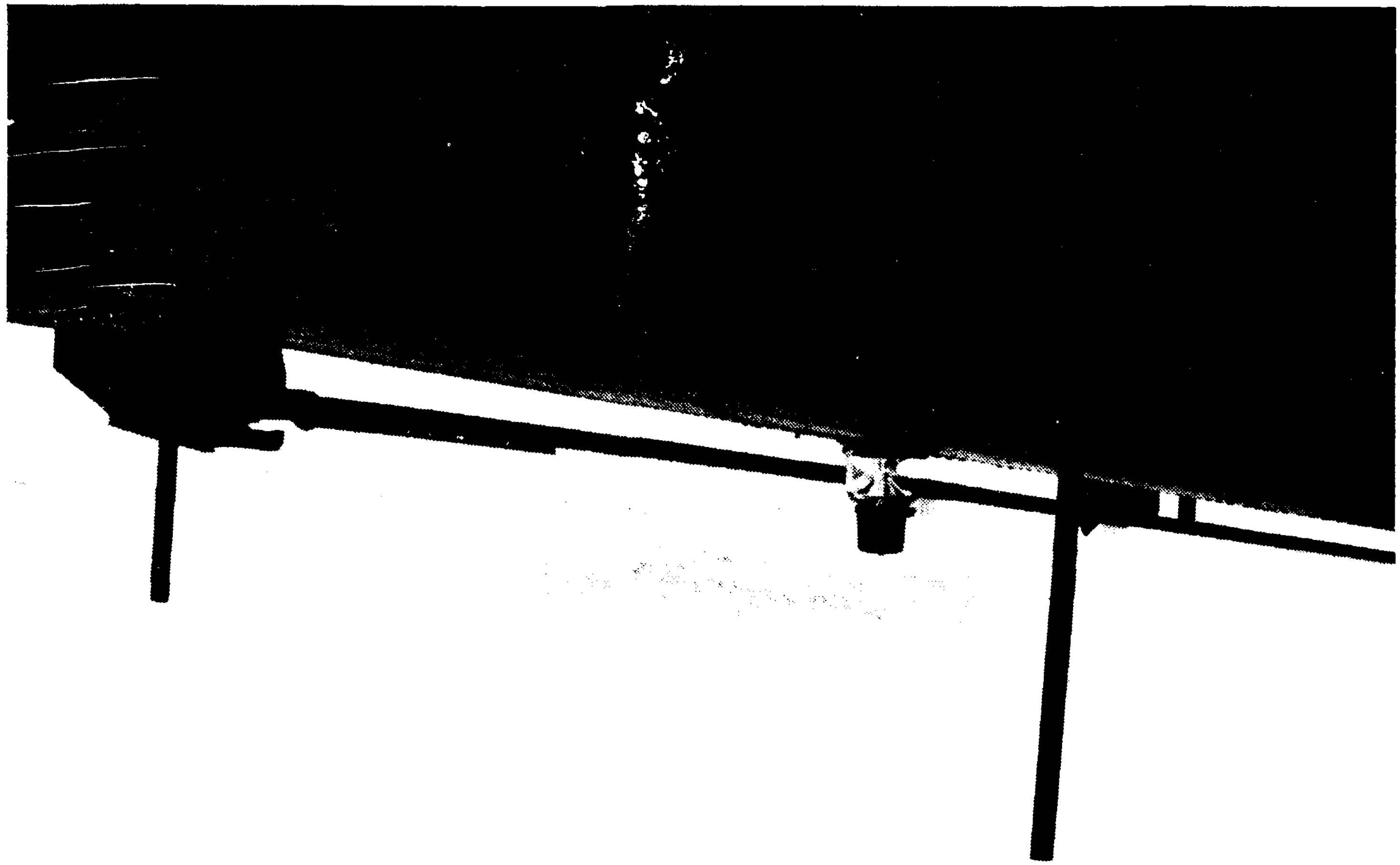

Photo 9. Ice Accretion on Electronic Countermeasure Antenna
Artificial Icing - 1.0 gm/m^3, -21.5°C, 49 Minutes, Flt #2

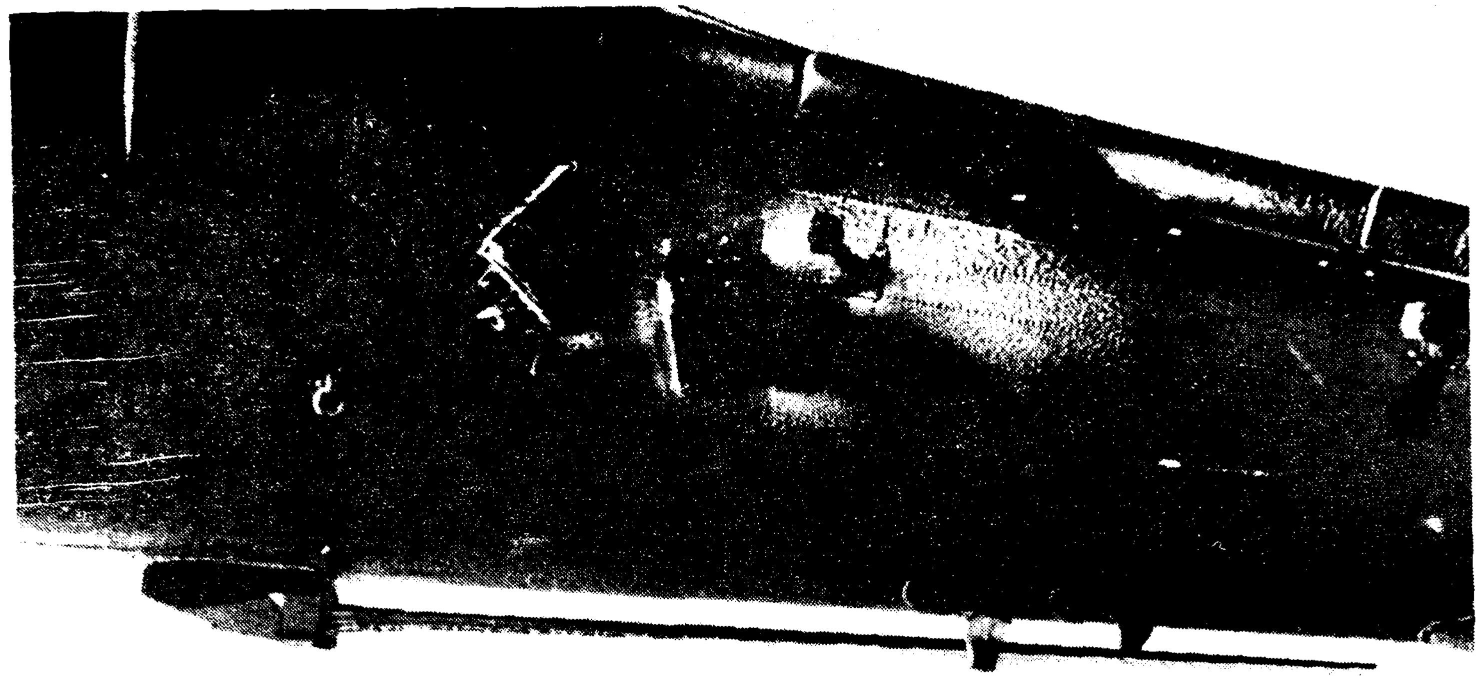

Photo 10. Induced Shedding - Electronic Countermeasures Antenna
Natural Icing - 0.25 gm/m^3 LWC, -5.5°C, 69 Minutes, Flt #12

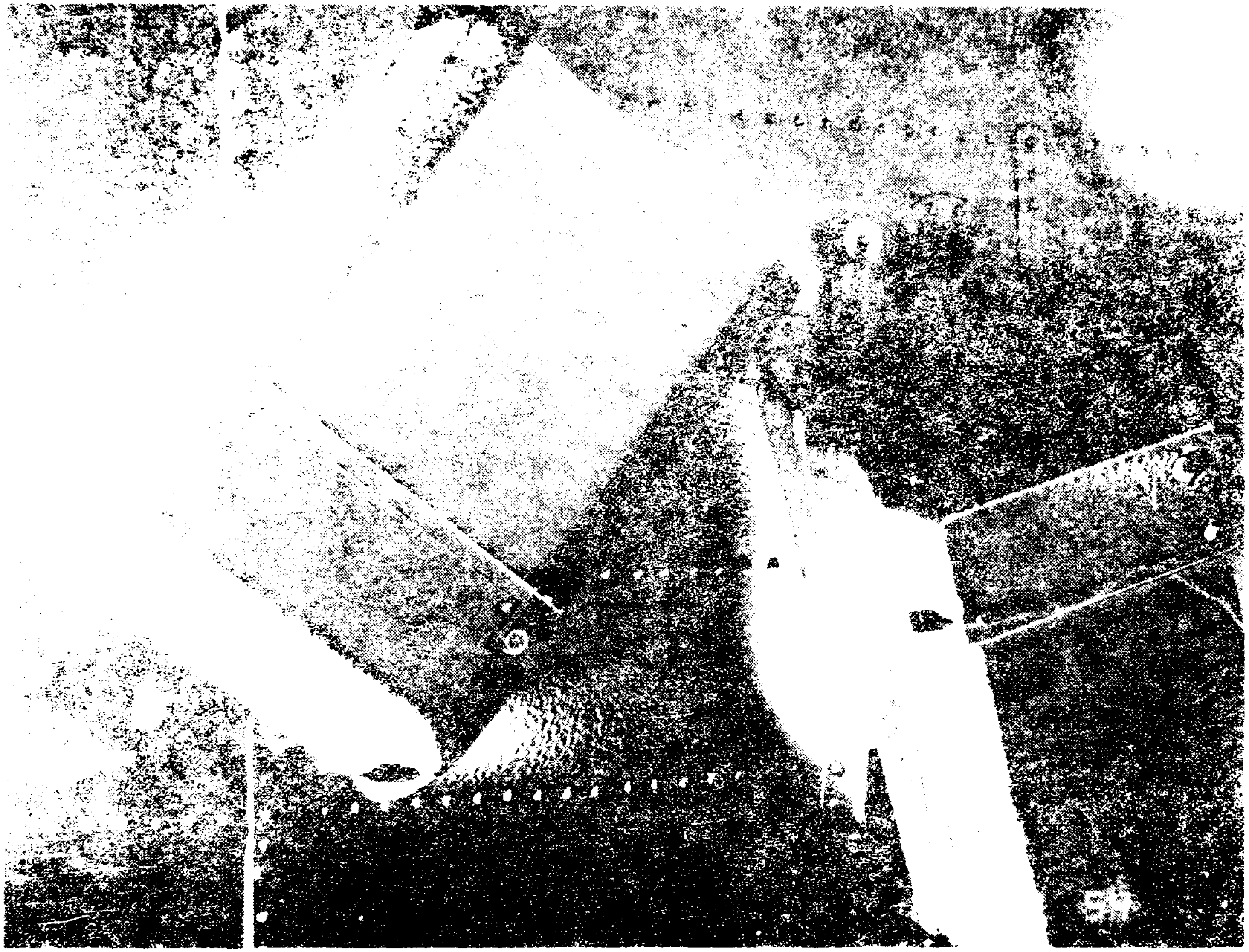

Photo 11. Ice Accretion M-130 Chaff/Flare Dispensers - Artificial Icing - 1.0 gm/m^3 LWC, -20.0°C, 28 Minutes. Fit #1

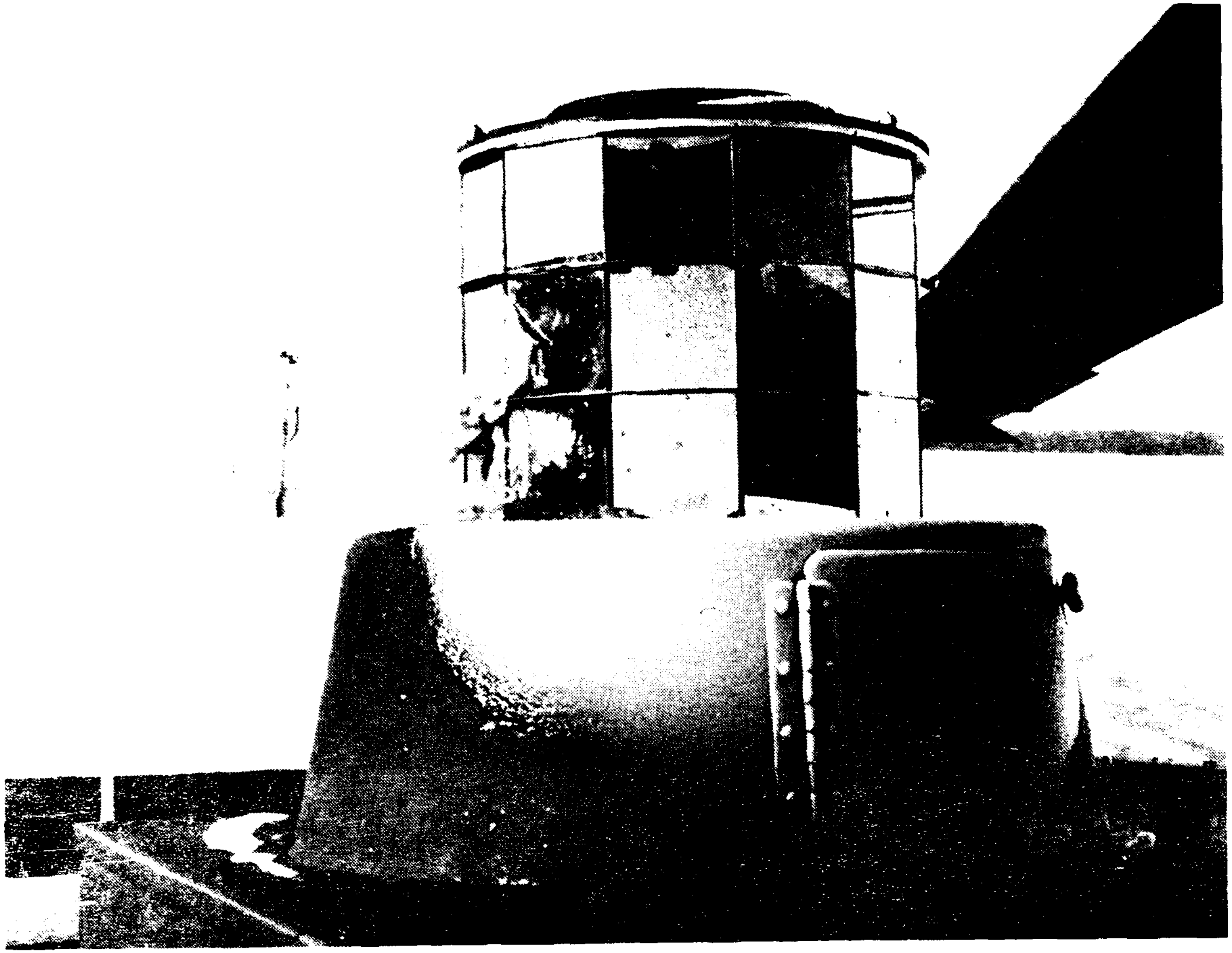

Photo 12. Ice Accretion - An/ALQ-144(V) Infrared Countermeasure Set
Artificial Icing - 1.0 gm/m^3 LWC. -20.0°C. 28 Minutes, Flt #1

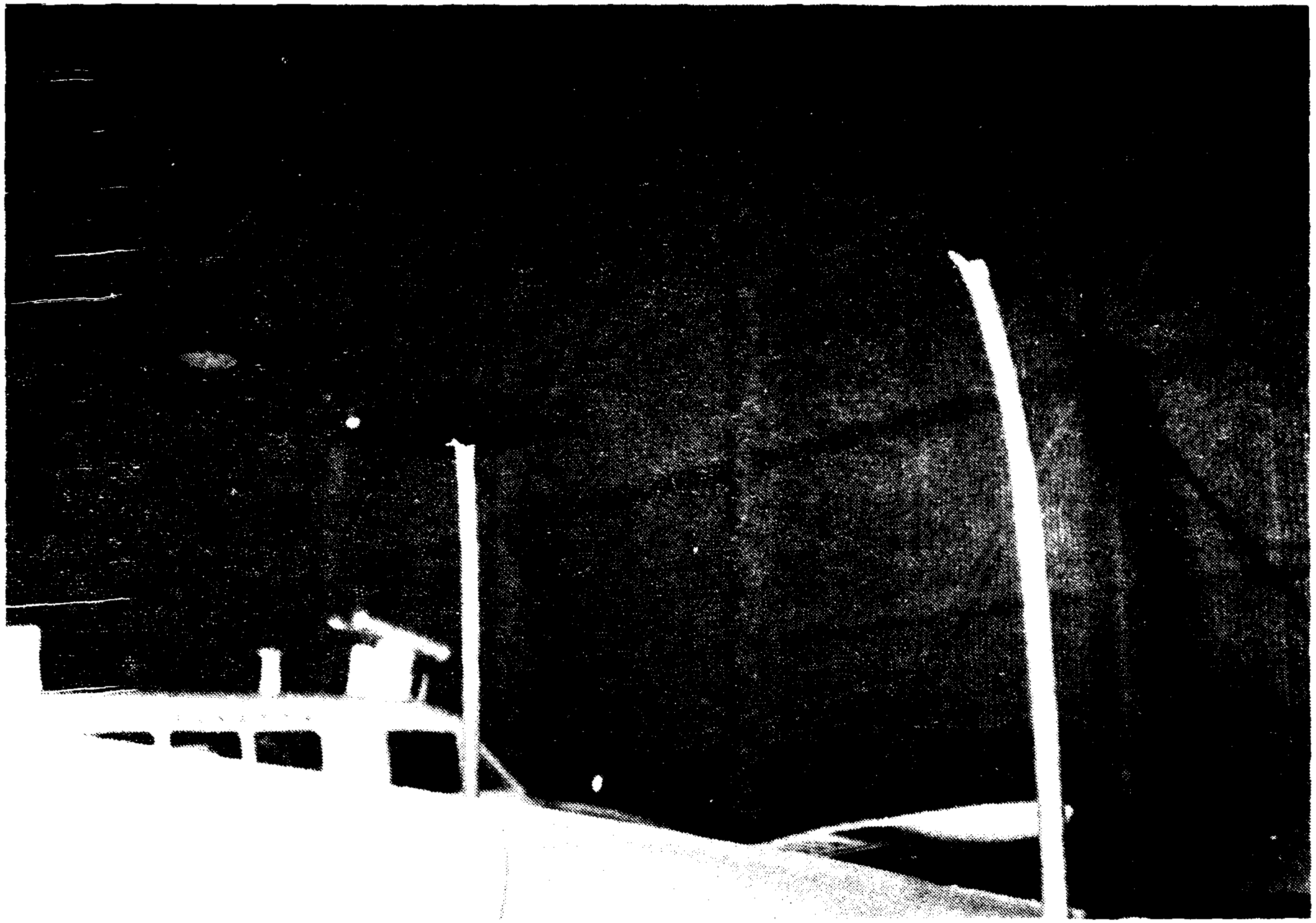

Photo 13. Ground Taxi Incident - Upper Element Damage
Direction Finding Antennas #3 and #4

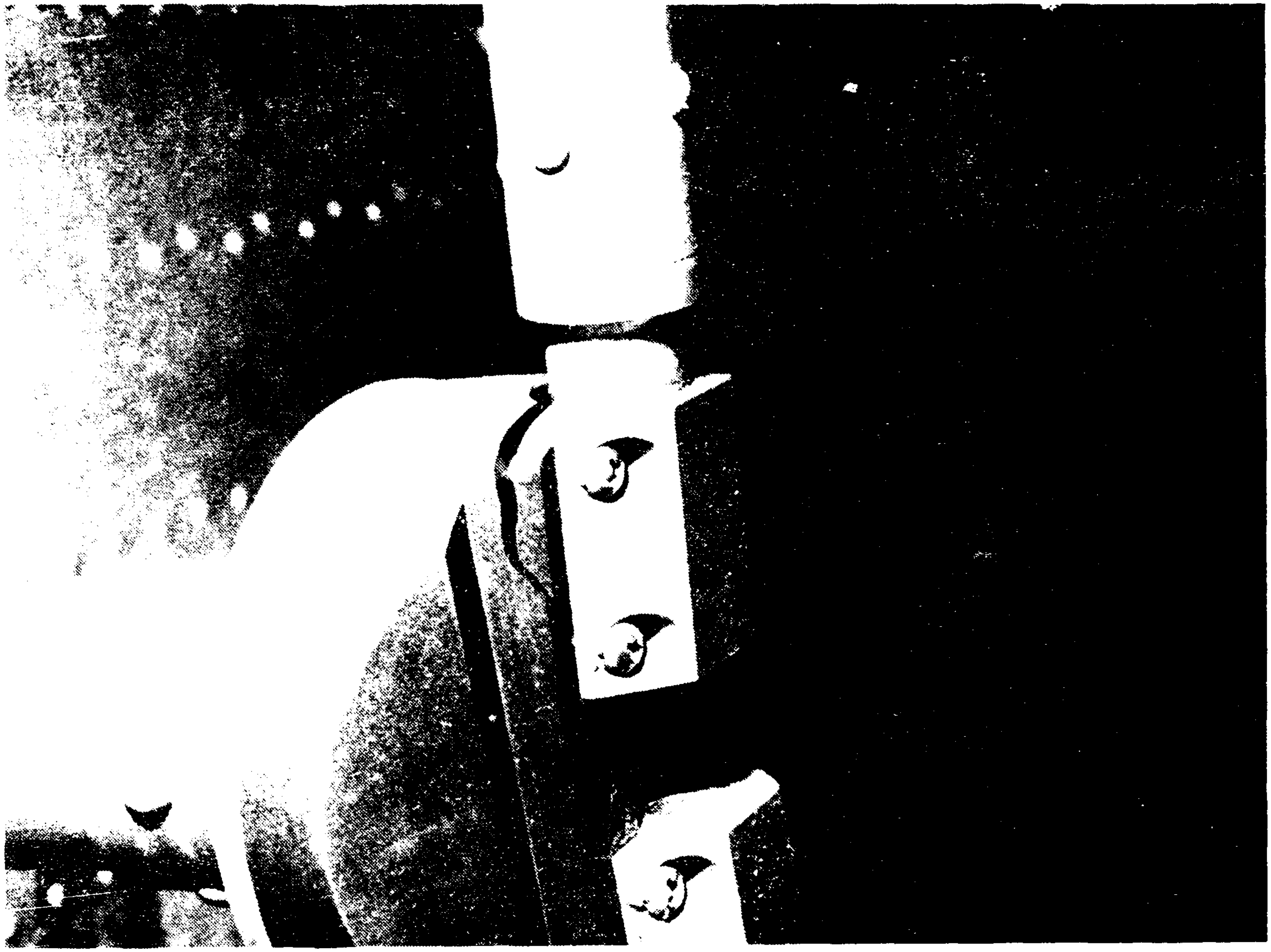

Photo 14. Ground Taxi Incident - Phenolic Block Damage

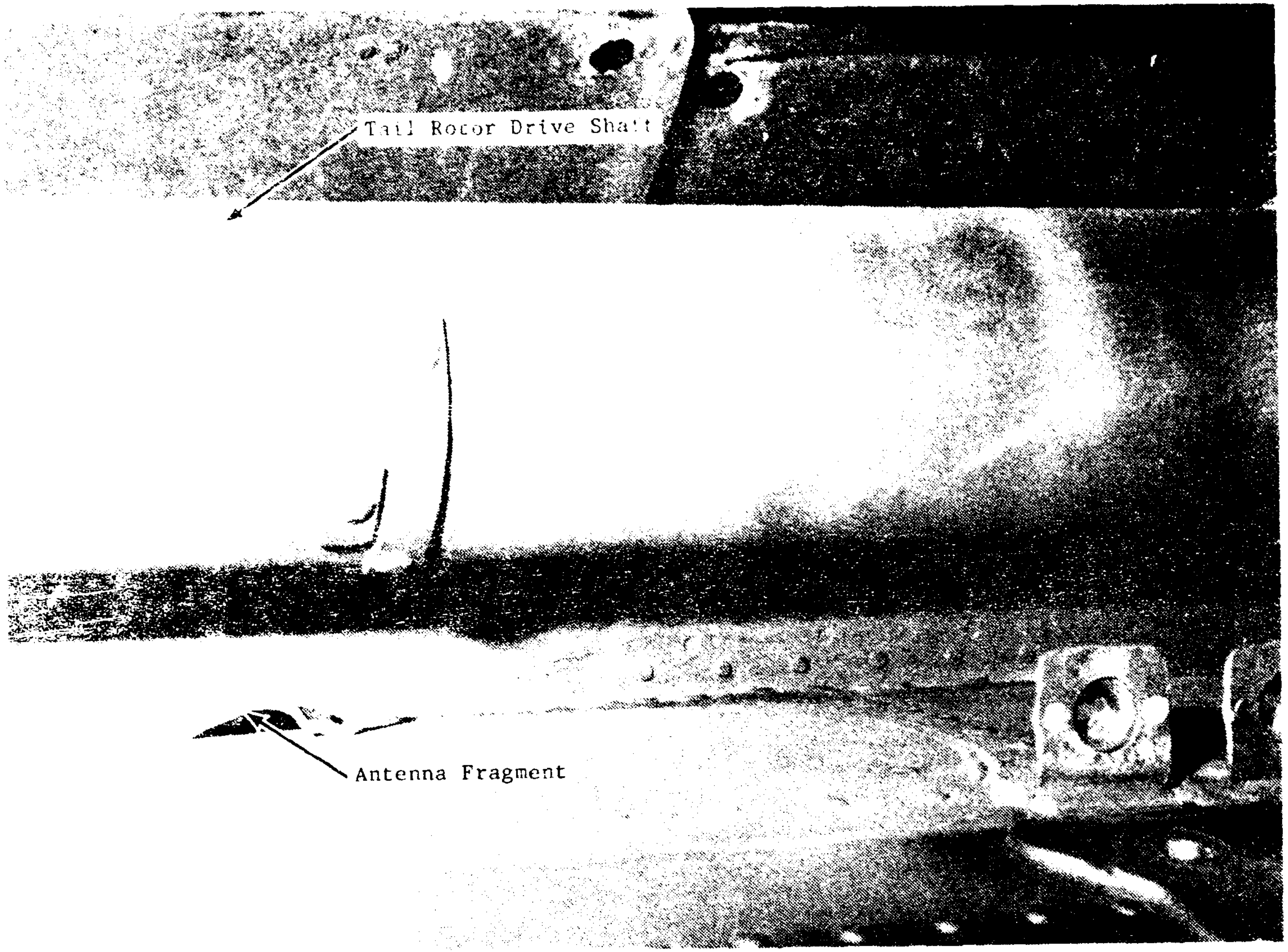

Photo 15. Ground Taxi Incident - Direction Finding Dipole Antenna #4 Fragment

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